OEC® 9800 C-Arm
Service Manual

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C-Arm Subsystem

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Circuit/Mechanical Descriptions

The following paragraphs describe basic electrical and physical features of the 9800 SERIES C-Arm Subsystem (referred to hereafter as the C-Arm). Subsequent chapters in this manual explain subsystem operation in functional concepts, focusing on how subsystem components interact in providing those functions. You can obtain additional information from the C-Arm Interconnect Diagram and Operators Manual, and the Workstation Operators and Service Manuals.

Subsystem Description

The C-Arms derive their name from the rigid, C-shaped weldment that supports the Image Intensifier, collimator, CCD Camera, and X-ray tube. These components together are commonly called the “C”, and the entire assembly from the casters up is known as the “C-Arm”.

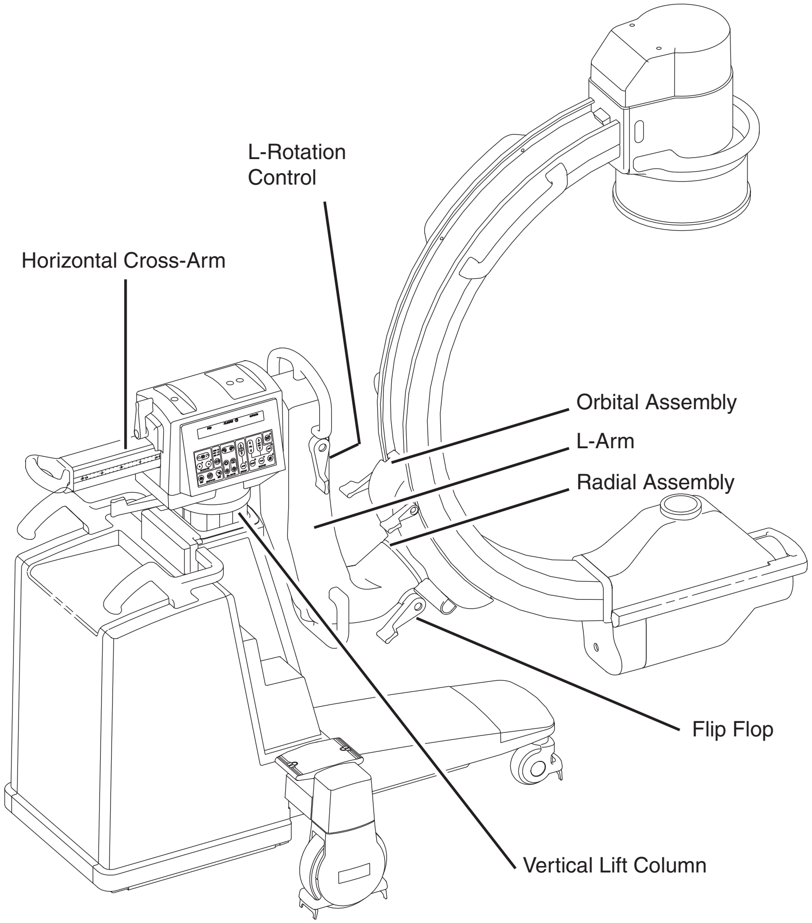
The X-Ray tube generates an X-ray beam that is shaped and oriented by the collimator. After passing through patient anatomy, the beam is directed onto a film cassette to produce a radiographic film image, or through the image intensifier and CCD camera (charge-coupled device), to convert the X-ray image to a video signal that is transmitted to the Workstation for display, processing, and storage.

There are several options and variations of C-Arm (see table following). Image Intensifiers are available in 9-inch and 12-inch sizes. The larger, more expensive II is often necessary for cardiac and vascular studies that require images of larger areas of the body. The smaller II is useful in extremity imaging and other routine applications.

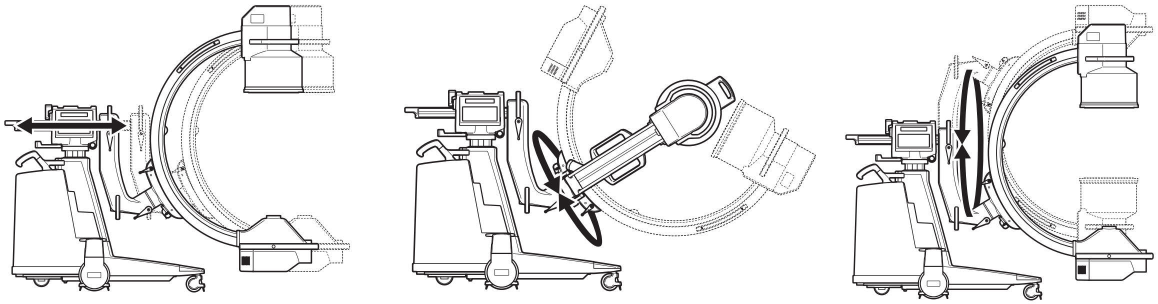
The Super C is often used in cardiac studies that require oblique views through the body, although it has proven useful in other applications as well. The Super C-Arm is similar to the standard C-Arm except that it has a larger diameter C, which mounts directly on the end of the Cross Arm. Due to geometric characteristics, there are variations in the types of motions of which each is capable (see following table).

A Cardiac C-Arm must be able to generate high technique in a pulsed mode to support dynamic cardiac and vascular studies. These studies can be recorded to disk or tape and replayed showing detailed, real-time movement. The Cardiac C-Arm capacity is increased by software options that enable the generator to produce higher technique X-ray pulses than the standard C-Arm.

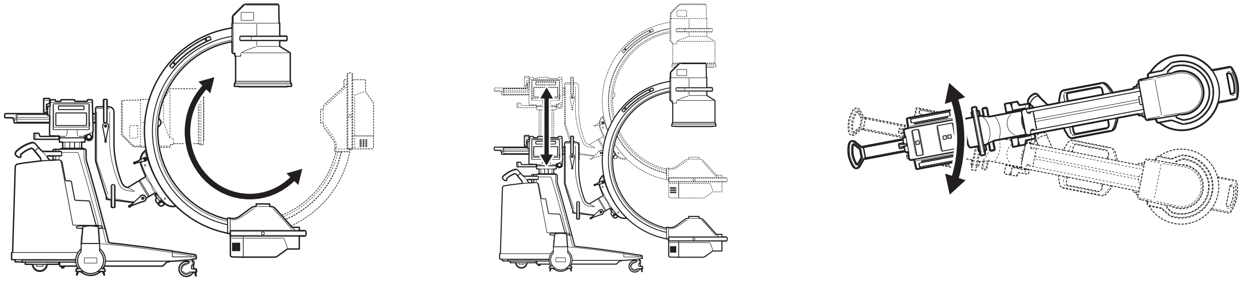
C-Arm Variation		
Standard C-Arm		**Super C**
Options	Cardiac	Cardiac
	Non-cardiac	Non-cardiac
	9-inch Image Intensifier	9-inch Imge Intensifier
	12-inch Imge Intensifier	---
Positioning	Wig Wag	Wig Wag
	L-Arm	L-Rotation
	Orbital	Orbital
	Flip Flop	---
	Horizontal Cross-Arm	Horizontal Cross-Arm
	Vertical Lift	Vertical Lift


L-Rotation
Control
Horizontal Cross-Arm
Orbital Assembly
L-Arm
Radial Assembly
Flip Flop
Vertical Lift Column

Standard C-Arm Mechanical Movement Systems

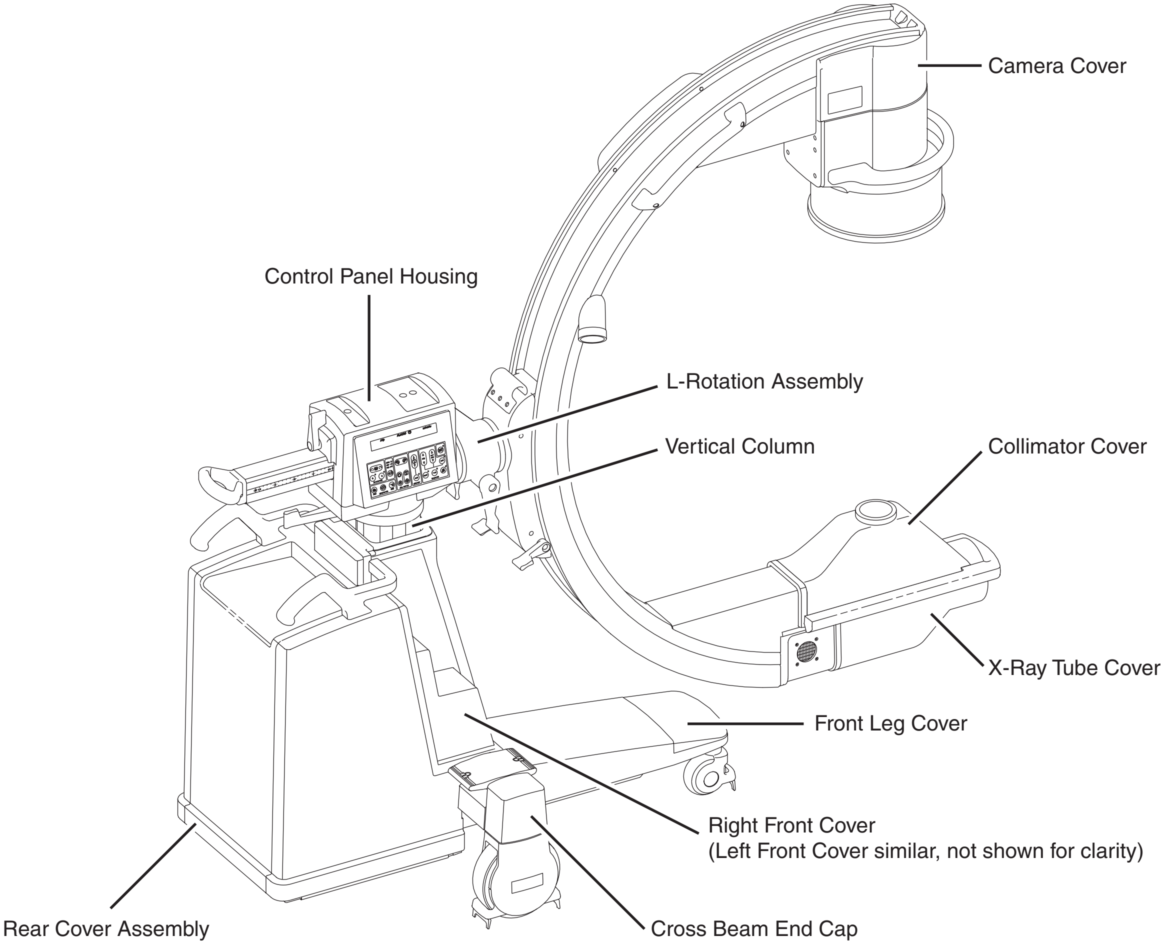


Horizontal Cross Arm *Flip-Flop* *L-Rotation*

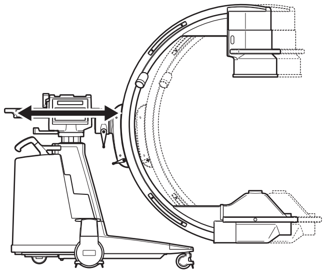


Orbital *Vertical Lift* *Wig-Wag*

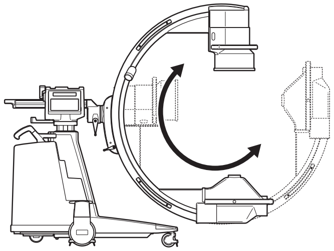
Standard C-Arm Motions


Camera Cover
Control Panel Housing
L-Rotation Assembly
Vertical Column
Collimator Cover
X-Ray Tube Cover
Front Leg Cover
Right Front Cover
(Left Front Cover similar, not shown for clarity)
Rear Cover Assembly
Cross Beam End Cap

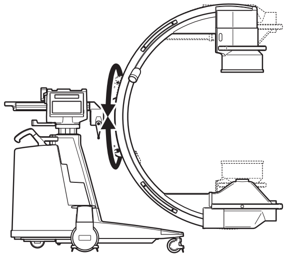
Super-C Mechanical Movement Systems



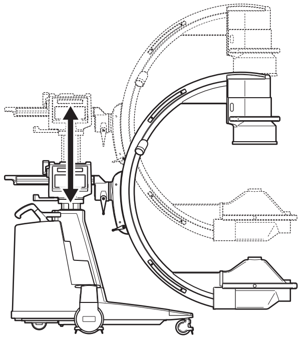
Horizontal Cross Arm



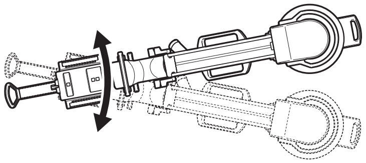
Orbital



L-Rotation



Vertical Lift

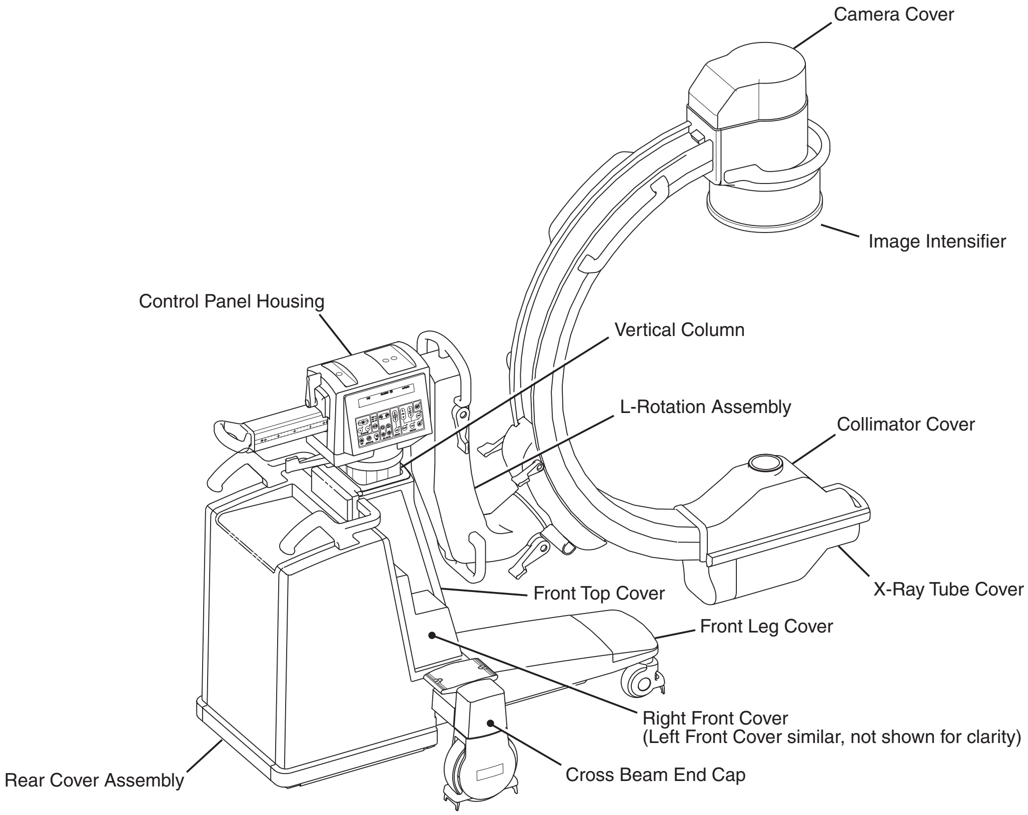


Wig-Wag

Super C Motions

Major Assembly and Control Locations

The following diagrams indicate the location of the major assemblies and controls of the standard C-Arm and the Super-C, or the covers by which they are accessed.

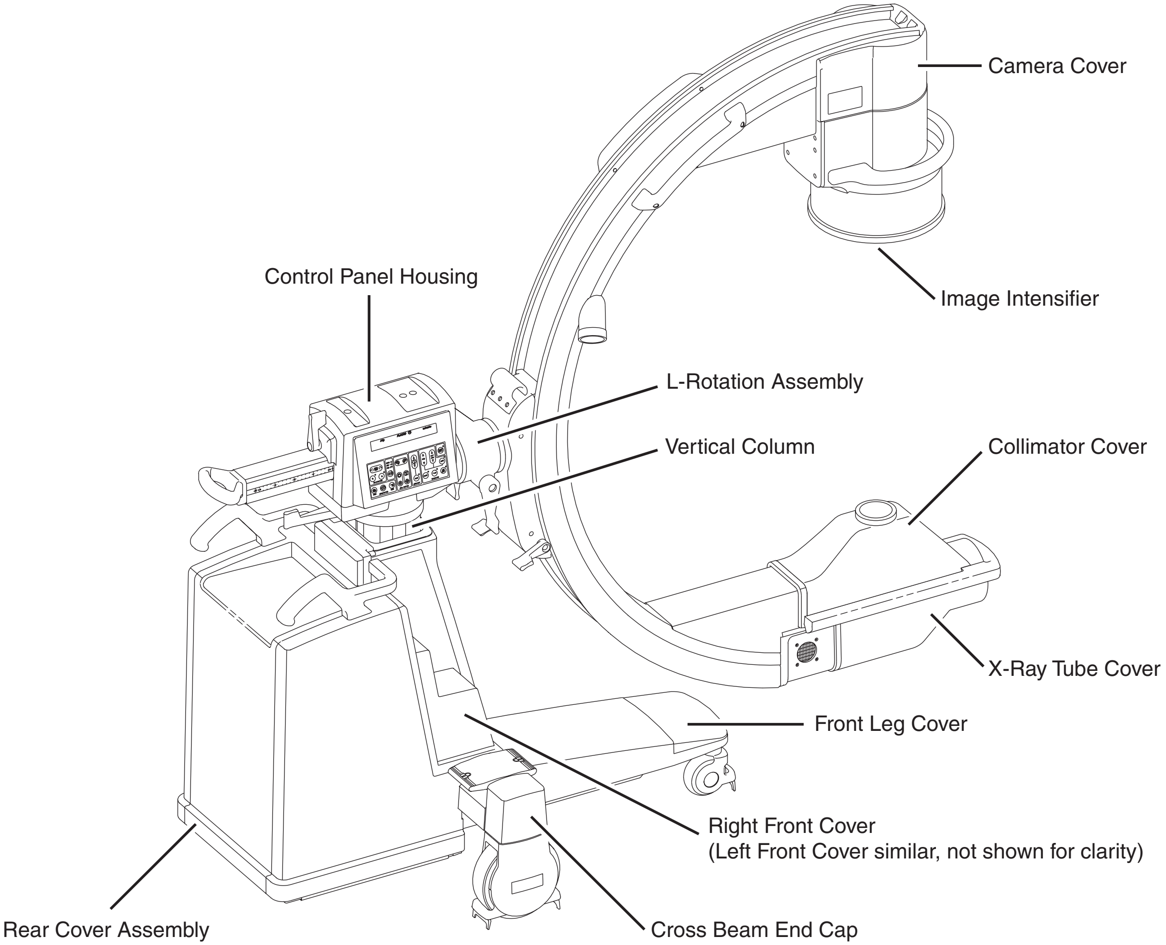

Camera Cover
Image Intensifier
Control Panel Housing
Vertical Column
L-Rotation Assembly
Collimator Cover
X-Ray Tube Cover
Front Top Cover
Front Leg Cover
Right Front Cover
(Left Front Cover similar, not shown for clarity)
Cross Beam End Cap
Rear Cover Assembly

Standard C-Arm Subsystem Major Assembly and Control Locations

The following table lists the primary components of the standard C-Arm associated with the major assemblies shown in the previous diagram, for the purpose of indicating physical location.

Location	Major Assemblies
Control Panel Housing Assembly	Left and Right Hand Control Panels Control Panel Processor I/O PCB Control Processor Assembly Vacuum Fluorescent Display (VFD) Modules (2)
Camera Cover	CCD Camera
Image Intensifier	Image Intensifier Power Supply
Vertical Column	Lift Column
L-Rotational Arm Assembly	L-Rotation Mechanical Assembly Flip Flop Gas Shock
Collimator Cover	Primary and secondary Collimator
X-ray Tube Cover	Thermal Switch Temperature Sensor X-ray Tube
Front Top Cover	Power/Motor PCB
Front Leg Cover	Front Caster Steering Chain Cable Pushers
Right Front Cover	Capacitor/Power Module
Left Front Cover	Stator/Pre-charge Transformer Multi-output Transformer (PS 2) Capacitors, Motor AC (2) Power/Signal Interface PCB Power Supply, +5/+12/±15 VDC (PS1)
Cross Beam End Cap (left and right sides)	Part of rear steering system

Location	Major Assemblies
Rear Cover Assembly	Mechanical linkage of rear steering system Battery Packs (2) C-arm Backplane PCB High Voltage Supply Regulator 486 X-ray Controller Assembly Fluoro Functions PCB Assembly Filament Driver PCB Assembly Generator Driver PCB Assembly High Voltage Tank IGBT/Snubber Assembly Power Supply, 24 VDC (PS 3) Battery Charger PCB and capacitors


Camera Cover
Image Intensifier
Control Panel Housing
L-Rotation Assembly
Vertical Column
Collimator Cover
X-Ray Tube Cover
Front Leg Cover
Right Front Cover
(Left Front Cover similar, not shown for clarity)
Rear Cover Assembly
Cross Beam End Cap

Super-C Subsystem Major Assembly and Control Locations

The following table lists the primary components of the C-Arm, associated with the major assemblies shown in the previous diagram, for the purpose of indicating physical location.

Location	**Major Assemblies**
Control Panel Housing Assembly	Left and Right Hand Control Panels Control Panel Processor I/O PCB Control Processor Assembly Vacuum Fluorescent Display (VFD) Modules (2)
Camera Cover	CCD Camera Image Intensifier
Vertical Column	Lift Column
L-Rotation Assembly	L-Arm Mechanical Assembly Gas Shock
Collimator Cover	Primary and secondary Collimator
X-ray Tube Cover	Thermal Switch Temperature Sensor X-ray Tube
Front Top Cover	Power/Motor PCB
Front Leg Cover	Front Caster Steering Chain Cable Pushers
Right Front Cover	Capacitor/Power Module
Left Front Cover	Stator/Pre-charge Transformer Multi-output Transformer (PS 2) Capacitors, Motor AC (2) Power/Signal Interface PCB Power Supply, +5/+12/±15 VDC (PS1)
Cross Beam End Cap (left and right sides)	Part of rear steering system

Location	Major Assemblies
Rear Cover Assembly	Mechanical linkage of rear steering system Battery Packs (2) C-arm Backplane PCB High Voltage Supply Regulator 486 X-ray Controller Assembly Fluoro Functions PCB Assembly Filament Driver PCB Assembly Generator Driver PCB Assembly High Voltage Tank IGBT/Snubber Assembly Power Supply, 24 VDC (PS 3) Battery Charger PCB and capacitors

Subystem Functional Breakdown

The operation of the C-Arm has been divided into the functional groups listed below. The functional group name corresponds to the applicable chapter tab in this manual, for easy access to the information indicated.

- AC Power Distribution
- DC Power Distribution
- Battery Charging
- System Communications
- Interlocks
- Stator Power and Control
- Pre-charge
- X-ray On, X-ray Disable
- kV Generation
- mA Generation
- Automatic Brightness Stabilization (ABS)
- Collimator
- Image Control
- Cooling
- Flip Flop
- Orbital Motion
- Wig Wag Motion
- Horizontal Cross Arm Motion
- L-arm
- Vertical Lift
- Steering and Braking

Functional Tests

Use the following tests to verify operational condition of the C-Arm. If the C-Arm fails any of these tests, refer to *Fault Isolation*, in this chapter.

Boot Test

1. With the Workstation off, unplug the interconnect cable from the C-Arm. . If the Workstation is already connected to the wall receptacle, you should hear a click from its internal electronics.
2. Verify that the Workstation AC Power plug is connected to the wall receptacle, or plug it in. You should hear one click from the Workstation as power is connected.

3. Turn on the Workstation. You should hear a click. The Workstation should boot without making any beeping sounds. Then turn it off.
4. Plug the interconnect cable into the C-Arm and listen for a click from the internal electronics of the Workstation. This click signifies that the Workstation is properly connected to the C-Arm and the AC voltage from the wall receptacle is at the proper voltage.
5. Verify the green “Battery” light on the C-Arm below the keyswitch is turned on about a second after the interconnect cable is plugged in, occurring at the time of the click in step 4.
6. Turn on the Workstation and verify that all LEDs on the C-Arm control panel come on at one time and the Vacuum Fluorescent Display illuminates a series of square patterns five at a time until the entire row of squares is ON.
7. Verify that the 20 arrows (>) on the C-Arm Vacuum Fluorescent Display light in succession until all 20 are lit, and then displays default technique settings 72kVp and 2.3mA. This signifies that the Workstation and C-Arm have successfully booted (this operation takes from 80 to 120 seconds depending upon configuration). No error messages should appear during bootup.

Fluoro Mode Performance Check

WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Boot the system as directed in the Boot Test section above, in this manual (if not already done).
2. Position the C-arm so that the X-ray head is directly above the image intensifier.
3. Place a suitable test object on the face of the image intensifier tube.
4. Set a technique of 72kVp/2mA.
5. Press the X-ray on switch. Verify that a digitized fluoro image of the object appears on the left monitor and that it remains there after the exposure is terminated.
6. Select AUTO mode is selected. Verify that the LED next to the AUTO key turns on.
7. Press the X-ray on switch. Verify that a digitized fluoro image of the object appears on the left monitor and that it remains there after the exposure is terminated. Inspect image for acceptable image quality.

8. Connect the footswitch and hand control and while pressing a footswitch or hand switch X-ray switch. Verify operation of the following:
    a. Image orientation keys: rotation and image reversal.
    b. Field size selection keys: NORM, MAG1 and MAG2.
    c. Motorized collimation controls: leaf rotation, iris collimation, and leaves open and close.
    d. The MODE switch (vascular systems only).

Film Mode Performance Check

WARNING: This procedure produces X-rays. Take the appropriate precautions.

1. Boot the system and perform the Fluoro Mode test, as directed in the Boot Test section above, in this manual,
2. Select FILM mode and enter the technique: 60 kVp @ 2.5 mAs.
3. Install the film cassette holder on the image intensifier and load a film cassette.
4. Press the footswitch. If the system has been idle for some time, listen for a whirring sound as the anode accelerates approximately 2 seconds before the X-ray switch indicator illuminates.
5. Release the footswitch after you hear three beeps.
6. Develop the film and inspect the exposure.

Mechanical Movement Check

Brakes

1. Engage the Wig-Wag brake and verify that the brake prevents Wig-Wag movement.
2. Tighten the Flip Flop brake and verify that the Flip Flop does not move.

3. Engage the C-Arm Orbital brake and verify that the C-Arm does not move.
4. Engage the Horizontal Cross-Arm brake and verify that the Cross-Arm does not move.
5. Engage the L-Arm brake and verify that the L-Arm does not move.
6. Engage the C-Arm wheel brake and then attempt to push the C-Arm. The wheels should not roll.

Wheels/Casters

Push the C-Arm and verify that the wheels roll smoothly, the casters turn freely and that the wheels are securely attached to the casters. Visually inspect the wheels for damage.

Wig Wag

Release the Wig-Wag brake and verify that the forward mechanics move laterally **approximately** ± 10° (20° total).

Flip Flop (Standard C-Arms only)

Release the Flip Flop brake and verify that the C-arm "flip-flops" through its entire range smoothly without roughness or vibration.

L-Rotation

Perform the following to verify radial rotation on Standard C-Arms and Super C-Arms:

1. On a standard C-Arm release the L-Arm brake and verify smooth rotation without roughness or vibration.
2. On a Super C-Arm release the L-Rotation brake and verify smooth rotation without roughness or vibration.

Orbital

Perform the following to verify orbital rotation for standard C-arms and Super C-arms:

1. On Standard C-arms, release the L-Arm brake and check C-arm rotation in the following positions:

   a. Position the C-arm parallel with the floor and lock the L-Arm brake. Rotate the C-arm through its entire range. The C-arm should rotate smoothly without vibration.
   b. Position the C-arm on the opposite side and lock the L-Arm brake. Rotate the C-arm through its entire range. The C-arm should rotate smoothly without vibration.
   c. Position the C-arm vertical to the floor, lock the L-Arm brake and rotate the C-arm through its entire range. The C-arm should rotate smoothly without vibration.

2. On Super C-arms, release the Flip Flop brake and check C-arm rotation in the following positions.
   a. Position the C-arm parallel with the floor and lock the Flip-Flop brake. Rotate the C-arm through its entire range. The C-arm should rotate smoothly without vibration.
   b. Position the C-arm on the opposite side and lock the Flip-Flop brake. Rotate the C-arm through its entire range. The C-arm should rotate smoothly without vibration.
   c. Position the C-arm vertical to the floor, lock the Flip-Flop brake and rotate the C-arm through its entire range. The C-arm should rotate smoothly without vibration.

Vertical Lift/

Boot the system, then press each vertical column motor switch through the full range of movement. During movement, press one of the Fast Stop buttons. Verify that vertical movement stops, X-ray function is disabled, and the system shuts down. The vertical lift should raise and lower fully and smoothly.

Horizontal Cross-Arm

Release the horizontal Cross-Arm brake and extend and retract the cross-arm. Verify that the cross-arm slides smoothly through the housing without binding.

Fault Isolation

Boot Test

If the C-Arm failed the Boot Test, use the following fault isolation chart:

Problem	**Probable Cause or Remedy**
No click heard when Interconnect cable is unplugged from C-Arm.	Workstation not plugged into wall receptacle; Receptacle not powered (fuse blown or circuit breaker tripped); 100-125V Workstation plugged into 200-250V outlet. Check Workstation power cord is correct voltage type for Workstation power as labeled. Check no external breakers CB1 through CB4 are tripped (white buttons are not protruding.) See *AC Power Distribution* chapter of this manual.
No click heard when Workstation plugged into AC power	100-125V Workstation plugged into 200-250V outlet; CB1 and/or CB2 tripped; Outlet power is off or breaker tripped.
Workstation beeps, does not boot, when switched on.	Isolation Transformer strapped incorrectly for applied AC voltage. Refer to *AC Power Distribution* chapter of this manual.
Workstation totally inoperative.	Check Workstation power and interconnect cables. 100-125V Workstation plugged into 200-250V outlet; CB1 and/or CB2 tripped; Outlet power is off or breaker tripped. Isolation Transformer strapped incorrectly for applied AC voltage. Refer to the *AC Power Distribution* chapter of this manual.
No click heard when Interconnect cable plugged into C-Arm.	Interconnect cable problem. Refer to *AC Power Distribution*..
Battery Charger light did not turn on.	Interconnect cable problem; Connector loose. Refer to *AC Power Distribution* chapter of this manual

Problem	Probable Cause or Remedy
All squares and arrows did not come on. Error message appears.	Refer to *Interlocks* chapter of this manual. Refer to *Bootup*, in the *Diagnostics* chapter of this manual.

Fluoro Mode

If the C-Arm failed the Fluoro Mode Performance Check, use the following fault isolation chart:

Note: The sections listed below are suggested starting points for your troubleshooting. It is likely that you will need to review other sections also.

Problem	Probable Cause or Remedy
No Fluoro image	Refer to the *kV and mA Generation* chapters of this manual.
Image quality unacceptable	Refer to *Image Intensifier and Power Supply* section in the *Image Control* chapter of this manual.
Rotation/image reversal	Refer to the *CCD Camera* chapter of this manual.
Field Size Selection	Refer to the *Image Intensifier Tube and Power Supply* chapter of this manual.
Collimation failure	Refer to the *Collimator Control* chapter of this manual.
Failure of MODE Control (vascular)	Refer to the *Image Intensifier Tube and Power Supply* chapter of this manual.
System shuts down without error messages	Refer to the *Cooling* chapter in this manual.

Film Mode

If the C-Arm failed the Film Mode Performance Check, use the following fault isolation chart:

Note: The sections listed below are suggested starting points for your troubleshooting. It is likely that you will need to review other sections also

Problem	**Probable Cause or Remedy**
No anode whirring sound	Refer to the *Stator Control* chapter of this manual.
No X-RAY ON indicator light	Refer to the *X-Ray ON and X-Ray DISABLE* chapter of this manual.
No beeps when footswitch pressed	Refer to the *kV Generation* and the *mA* Generation chapters sections of this manual.
Exposure unsuitable	Refer to the *kV Generation and mA Generation* chapters of this manual.

Mechanical Movement

If the various checks for mechanical movement indicate a fault, refer to the applicable chapter for that movement, later in this manual.

AC Power Distribution

Circuit/Mechanical Descriptions **2**
- AC Power to PS1 and PS2 2
- AC Power to PS3 4
- AC Power to the Battery Charger and Light 5
- AC Power to the Stator 5

Functional Tests **6**
Fault Isolation **6**
Adjustment **8**
Miscellaneous **8**

Circuit/Mechanical Descriptions

For purposes of this description, assume the Workstation is connected to facility power correctly, and the Workstation and C-Arm are correctly connected via the Interconnect Cable. Before you turn on the Workstation power switch, 115VAC_PH is present at connector P5 of the C-Arm Power/Signal Interface PCB, and energizes the battery charger light and the battery charger. However, at this point, no power is available for any other C-Arm circuits.

When you turn on the workstation, KEY POWER is turned on, and connects 115VAC_PH to the other C-Arm circuits, thus initiating the bootup process.

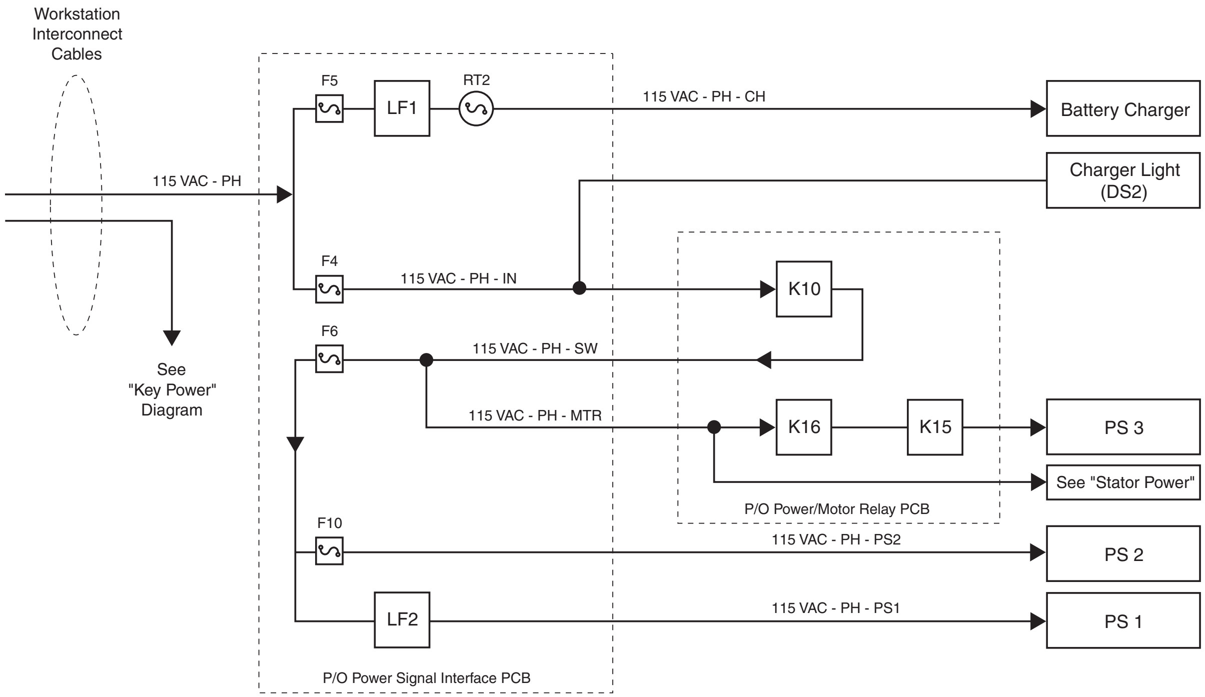
In addition to the battery charger, AC power is distributed to Power Supply PS1, PS2, PS3, and the stator, as illustrated in the following diagram:

Note: For clarity, the return connections are not described in the following circuit descriptions. These descriptions are intended only to show you how things work, not to go into full details of the entire power system.

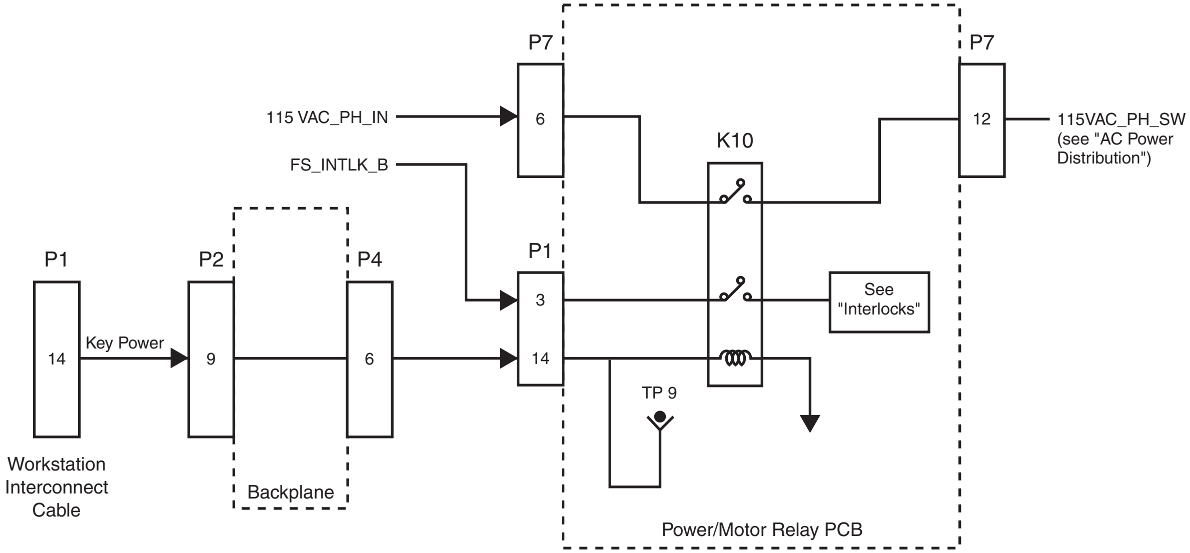
AC Power to PS1 and PS2

Whenever the Workstation power switch is on, PS1 and PS2 are held energized by Key Power as follows:

1. On the Power Signal Interface PCB, incoming operating power (115VAC_PH) flows through fuse F4, then leaves the PCB as 115VAC_PH_IN.
2. The 115VAC_PH_IN enters the Power Motor Relay PCB, and goes to the input contact of the K10 relay. When the contact is switched, the power returns to the Power Signal Interface PCB as 115VAC_PH_SW.
3. Key Power furnished by the Workstation via the Interconnect cable energizes the K10 relay coil when the Workstation is turned on. Refer to the following diagram:
4. For PS1, the 115VAC_PH_SW passes through Fuse F6 and Line Filter LF2 on the Power/Motor Relay PCB, and exits at Connector P9.
5. For PS2, the 115VAC_PH_SW passes through Fuse F6 and Fuse F10, on the Power/Motor Relay PCB, and exits at connector P4.


Workstation
Interconnect
Cables
115 VAC - PH
See
"Key Power"
Diagram
F5
LF1
RT2
115 VAC - PH - CH
Battery Charger
Charger Light
(DS2)
F4
115 VAC - PH - IN
K10
F6
115 VAC - PH - SW
115 VAC - PH - MTR
K16
K15
PS 3
See "Stator Power"
P/O Power/Motor Relay PCB
F10
115 VAC - PH - PS2
PS 2
LF2
115 VAC - PH - PS1
PS 1
P/O Power Signal Interface PCB

AC Power Distribution


P7
P7
115 VAC_PH_IN
6
12
115VAC_PH_SW
(see "AC Power
Distribution")
K10
FS_INTLK_B
P1
P2
P4
P1
3
See
"Interlocks"
14
Key Power
9
6
14
TP 9
Workstation
Interconnect
Cable
Backplane
Power/Motor Relay PCB

Key Power Distribution

AC Power to PS3

a. AC power comes from K10 in the Power/Motor Relay PCB and goes into the Power/Signal Interface PCB as 115VAC_PH_SW, as described above.

b. Rather than pass through F6 as above, a separate path loops back out to the Power/Motor Relay PCB as 115VAC_PH_MTR.

c. The 115VAC_PH_MTR connects to the K16 relay, then in series to the K15 relay. With the relays in switched state, the signal becomes MOTOR_115VAC, exiting the PCB and connecting to PS3. As with PS1 and PS2, PS3 is held energized through the K10 relay.

d. PS3 is further controlled by the coils of the K16 and K15 relay, which are energized as described in the *Lift Column* section of this manual.

AC Power to the Battery Charger and Light

a. With the Workstation either on or off, 115VAC_PH enters the Power Signal Interface PCB, flows through fuse F5, Line Filter LF1, and the inrush current limiter RT2, then leaves the PCB as 115VAC_PH_CH. This power then connects to the Battery Charger PCB. In this manner, power is always available at the battery charger whether or not the Workstation or C-Arm is operating.

b. The Battery Charger Indicator Lamp, mounted on the C-Arm Interface Panel, is energized by the 115VAC_PH_IN power, as described in *AC Power to PS1and PS2*, above in this section. The significance of this connection is that the Battery Charger Indicator Lamp will be illuminated at all times that the Workstation is correctly connected to facility power. This is a safety feature, warning personnel that power exists in the C-Arm even when the Workstation is not operating.

c. Whenever the Interconnect Cable is disconnected from the C-Arm, AC power is removed from the pins supplying the C-Arm AC input power, for safety reasons. If the Interconnect Cable is plugged in while the Workstation is connected to facility power, the C-Arm power is turned on after a short delay of about a second. This also applies if a complete system is plugged into facility power.

WARNING: Full operating power (115 VAC single phase) exists at the intervening circuit connections, even if the C-Arm failed to complete boot-up.

AC Power to the Stator

The 115VAC_PH_MTR, as described above, is under the control of Relay K10 on the Power/Motor Relay PCB. This power divides two ways-one to the K15/K16 relays as described above. The other branch is conducted to the K1 relay on the same PCB, which is controlled by circuitry explained in the *Stator Power and Control* section.

Functional Tests

None

Fault Isolation

Use the following troubleshooting guide to eliminate the AC power components as failure candidates.

Failure	Possible Cause	Remedy
With Workstation off, battery charger light is **OFF**.	Workstation power problem.	Check that Workstation power and interconnect cables are plugged in. Check CB1, and CB2 if present. Check CB3. (White buttons should be flush, not protruding)
	100-125V system plugged into 200-250V.	Wrong power cord for 200-250V system. Replace with proper cord or connect to proper voltage.
	Loose connectors	Check Power/Signal Interface PCB connectors.
	Power Control PCB (in Workstation) jumper E1 set to 2800 position.	Set jumper to 9800 position.
	Blown fuse F4 on Power/Signal Interface PCB.	Replace fuse.
C-arm completely inoperative; no error messages; battery charger light is **ON**.	Buzzer sounds when Workstation switched on.	Incorrect tap settings on Isolation Transformer. Measure AC line voltage and set taps to proper voltage setting.
	No Key Power	Refer to Workstation Service Manual
	Loose connectors	Check Power/Signal Interface PCB connectors.

Failure	**Possible Cause**	**Remedy**
	Blown fuse F6 or F10 on Power/Signal Interface PCB.	Replace fuse.
	DC power distribution problem.	See *DC Power Distribution* section in this manual.
	Defective Relay K10 in Power/Motor Relay PCB	See *AC Power Distribution* diagram in this chapter.
Workstation boots but nothing on C-arm. Battery Charger Light ON	Power Signal Interface	Check AC into and out of Power Signal Interface.
	Fast stop buttons or wiring open	Check connectors and buttons.
	F10 Fuse on Power/Signal Interface PCB	Check F10
Workstation boots but nothing on C-arm. Battery Charger Light OFF	Interconnect Cable	Check AC power pins at Lemo connector in C-Arm, also check continuity between pins 19-24 and pin 22 to ground.
	Power Control PCB in Workstation	Check CB3 and CB4 in Workstation
Lift column inoperative	Loose connectors.	Check connectors on Power/Motor Relay PCB and PS3 inputs.
	No MOTOR-115-AC to PS3, caused by Defective K15 or K16 on Power/Motor Relay PCB	Relays are not FRUs. Replace Power/Motor Relay PCB.
	Lift column control problem	Refer to “Vertical Column” section in this manual.

Adjustment

(None)

Miscellaneous

None

Section 2 - Overview

This section provides an introductory technical description of the OEC Workstation. It is organized as follows:

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References

Refer to Workstation Interconnect Diagram 00-878981 as you read this section.

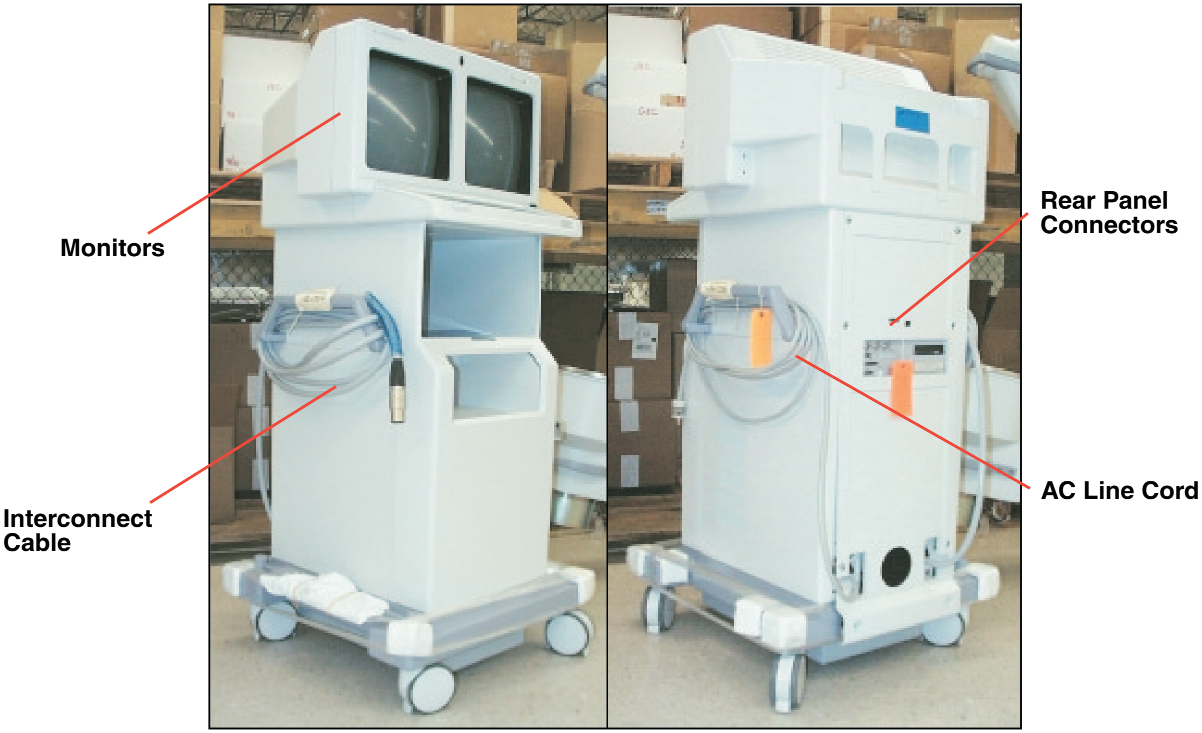
Major Functions

The OEC Workstation provides most of the user interfaces and all of the external data interfaces in an OEC mobile digital imaging system. It also performs the system's computing and image manipulation functions such as post processing and storage. The Workstation also provides AC power conversion, distribution, and monitoring, directs many automated functions, and reports system conditions to the operator to ensure safe and accurate system operation.

Physically, the Workstation consists of two high-resolution video monitors mounted on a moveable cart equipped with a keyboard and other user interfaces. The AC line cord that powers the Workstation and image generator enters the rear of the Workstation, as does the system interconnect cable that carries power to, receives video from, and exchanges data with the X-Ray generator. The Workstation contains many electronic assemblies, and can be equipped with optional devices such as a VCR or dye diffusion printer.

When the Workstation connects to an X-Ray generator, it can capture and process live fluoroscopic images. It can also be used as a standalone device for viewing and postprocessing stored images.

A typical Workstation appears on the following page.


Monitors
Interconnect Cable
Rear Panel Connectors
AC Line Cord

WorkStation Components

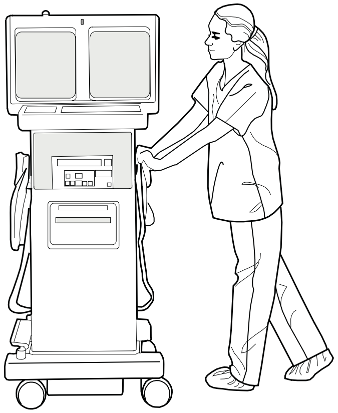
Major Components

Major internal Workstation components include the Host Controller, Display Subsystem, Cine Disk Subsystem, Image Subsystem, User Interface, External Interface, and Power Distribution Subsystem.

The following paragraphs first describe the mechanical characteristics of the Workstation, and then discuss each of the major components.

Mechanical Details

The basic Workstation without any optional equipment weighs about 400 pounds (182 kg) and stands about 64 inches (163 cm) high. Its wheelbase is about 27.5 by 27.5 inches (70 by 70 cm). One person can safely move the Workstation over level flooring or carpet.

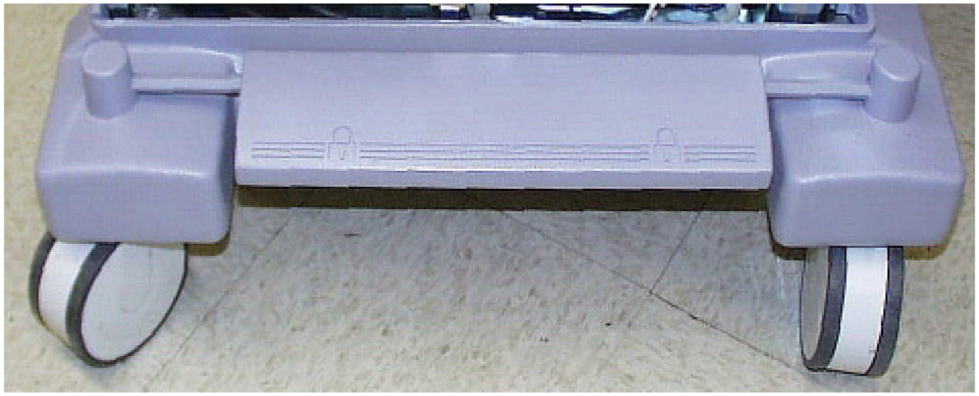


Workstation is Safe and Easy to Move

Locking the Workstation Casters

The Workstation brake pedal has three positions:

1. The **UP** position locks two of the four Workstation casters facing straight ahead, making it easier to push the Workstation longer distances, such as down a hallway.
2. The **CENTER** pedal position permits all casters to pivot freely so you can maneuver the Workstation around corners and obstacles. Use this pedal position when placing the Workstation in its final operating location.



Brake Pedal

Workstation Moving Precautions

***WARNING**: Never move the Workstation up or down an incline of greater than 10 degrees. It may roll out of control.*

***WARNING**: Get another person to help you when moving the Workstation up or down an incline. It may roll out of control.*

***WARNING**: Never attempt to move the Workstation up or down steps. Personal injury or equipment damage may otherwise result.*

***WARNING**: Never lock the Workstation in place on an incline. It may tip over.*

***CAUTION**: Move the Workstation separately from other imaging system equipment.*

***CAUTION**: Be careful of people and obstructions when moving the Workstation. Even low-speed collisions can result in significant personal injury and equipment damage.*

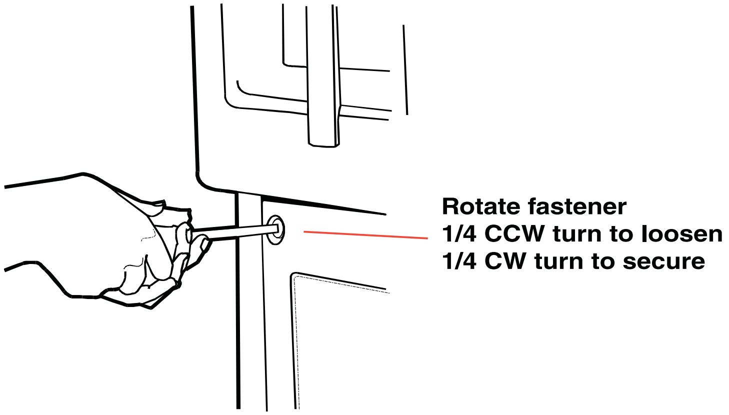
Cover Removal

***WARNING**: Removing any Workstation cover exposes dangerous electrical voltages on several components. When possible, disconnect Workstation from AC line before removing any covers. When it is necessary to leave the power applied, use extreme care to avoid death or injury from electrical shock.*

***Note**: Set the brake before attempting to remove Workstation covers.*

The Workstation's rear, side, and front covers are removable, as is the monitor cover. However, you must first remove the rear cover before you can remove the side or front covers. You can remove the monitor cover at any time.

Eight quarter-turn fasteners hold the rear cover in place. You must loosen all eight fasteners before you can remove the rear cover.

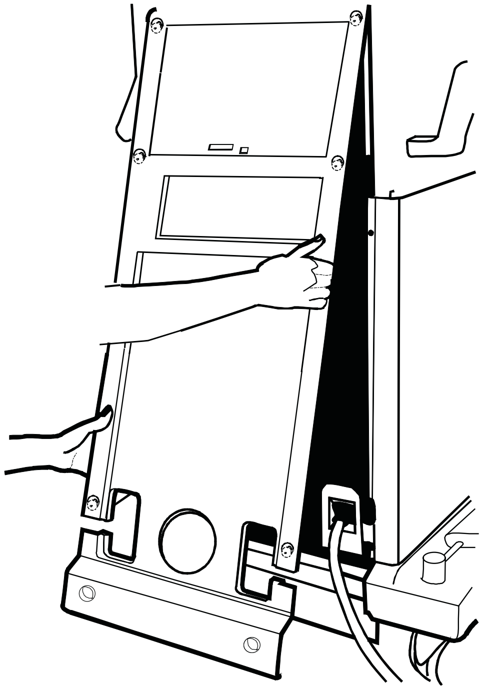


Quarter-Turn Fasteners

Rear Cover Removal

Follow these steps to remove the rear cover:

1. Loosen eight quarter-turn fasteners that secure rear cover to Workstation chassis.
2. Move the bottom of rear cover outward a few inches, and then pull cover downward and outward.



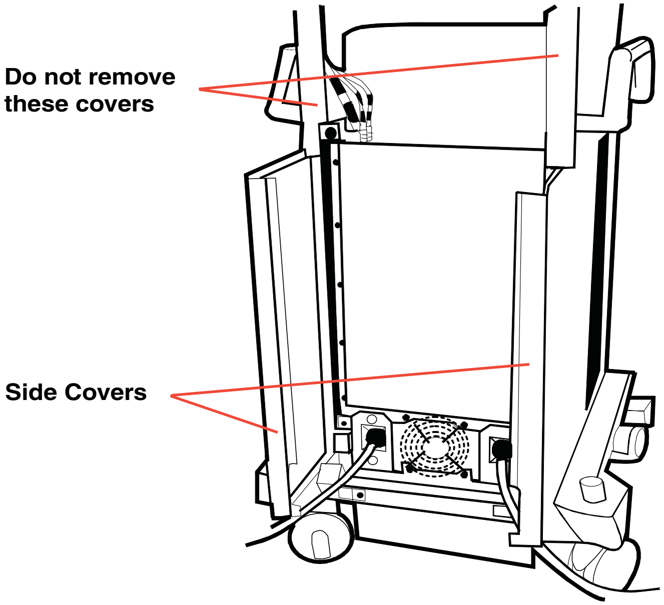
Rear Cover Removal

Side Cover Removal

***Note**: Rear cover must be removed before side covers or front cover can be removed*

***Note**: Left and right side covers fit into slots in Workstation base and under handles on either side of Workstation.*

Remove both side covers by pulling each of them to the rear of the Workstation.

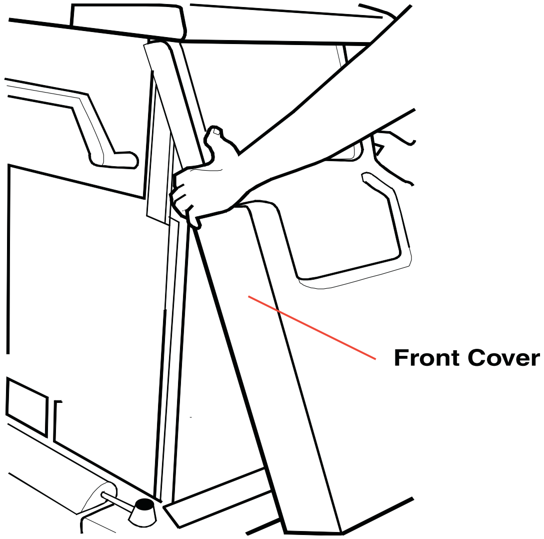


Side Cover Removal

Front Cover Removal

***Note**: Rear cover and side covers must be removed before front cover can be removed*

1. Using both hands, grasp front cover near bottom of cover.
2. Giving equal pressure with both hands, lift front cover upward to disengage two ball-nut fasteners on bottom edge of cover.
3. Move front cover upward under keyboard.
4. Move front cover outward, then downward to free it from Workstation.

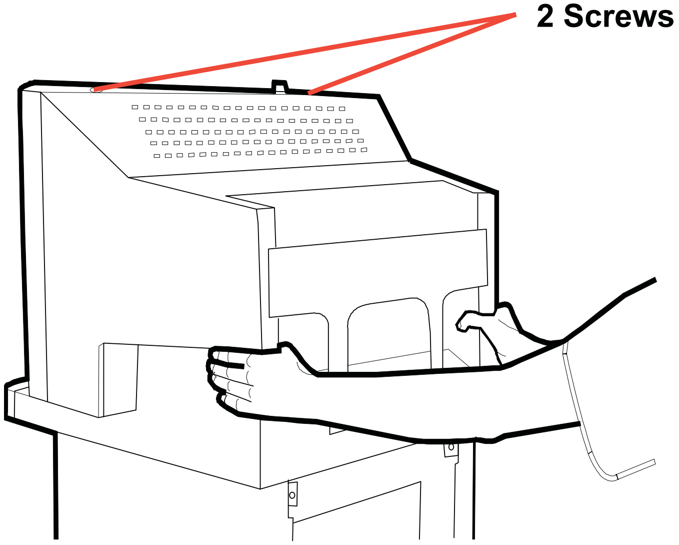


Front Cover Removal

Monitor Cover Removal

***Note**: Ball-nut fasteners hold bottom of monitor cover to front of monitor chassis.*

1. Remove two torx screws at top of cover.
2. Grasp monitor cover with both hands.
2. Pull monitor cover away from Workstation to free ball-nut fasteners from front of monitor chassis.

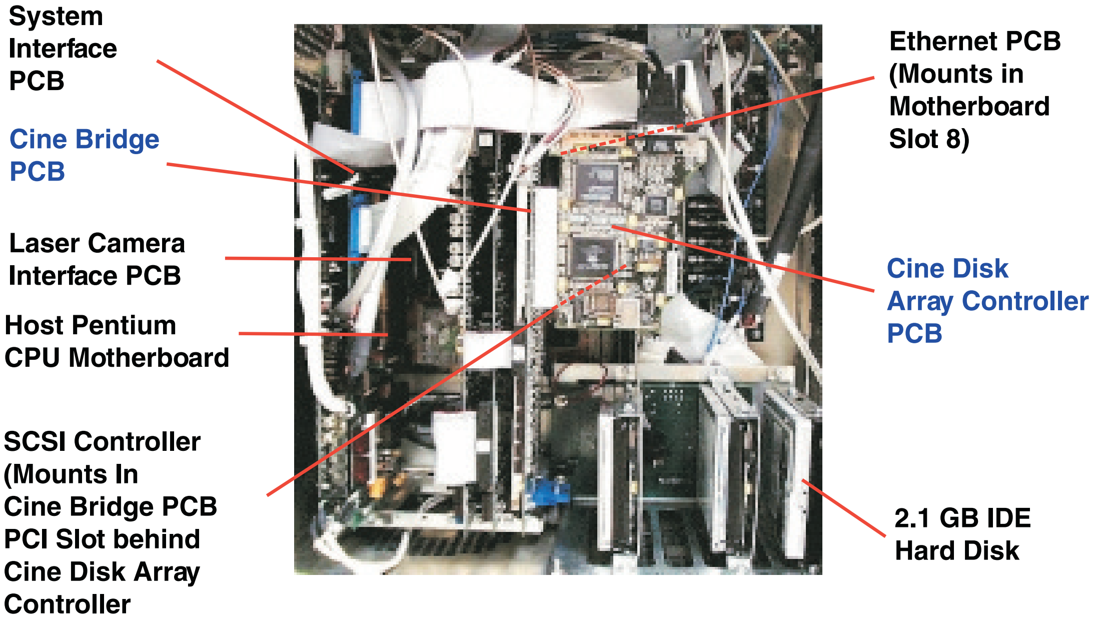


Monitor Cover Removal

Host Controller

The following is a basic description of Host Controller hardware. Refer to **Section 4 - Host Controller** for detailed circuit descriptions, troubleshooting information, and component replacement instructions.

The Host Controller manages image acquisition, image processing, image display and annotation, image storage, and user communications. Host Controller circuitry consists of a high-performance Host Pentium CPU motherboard, System Interface PCB, SCSI Controller PCB, Ethernet® (DICOM) Interface, Laser Camera Interface, IDE Hard Disk Drive, and 3.5-inch floppy disk drive. These devices reside in the Electronics box, located near the base of the Workstation.


System Interface PCB
Cine Bridge PCB
Laser Camera Interface PCB
Host Pentium CPU Motherboard
SCSI Controller (Mounts In Cine Bridge PCB PCI Slot behind Cine Disk Array Controller
Ethernet PCB (Mounts in Motherboard Slot 8)
Cine Disk Array Controller PCB
2.1 GB IDE Hard Disk

Host Controller Components in Electronics Box

Host Pentium CPU Motherboard

Nearly all Workstation functions are software controlled. The software executes in a multi-processor environment in the Host Pentium CPU, which communicates over the ARCNet bus to control the other intelligent devices in the Workstation and in the X-ray generator.

When the Workstation powers up, the Host Pentium CPU loads system or diagnostic software from a 1.44 Mb floppy disk mounted in the floppy disk drive located at the rear of the Workstation. If the floppy disk drive is empty (usually the case) the host Pentium CPU instead loads system software from the Workstation IDE hard disk drive. Following a successful boot-up with software loaded into memory, the motherboard begins various run-time chores such as initializing intelligent peripheral devices and processing user inputs.

The motherboard has four 16-bit ISA slots, three of which are used. These slots are usually populated with the System Interface PCB, optional Laser Camera Interface, and Video Controller PCB. The spare ISA bus slot is normally empty, but it can accommodate a VGA video card for diagnostic purposes.

There are four 32-bit PCI bus slots, all of which are used. These slots support the Display Controller PCB, Image Processor PCB, Cine Bridge or SCSI Controller, and Ethernet (DICOM) card.

Single Board Computer and Passive Backplane

Earlier versions of the Host Controller consisted of a standard Socket 7 motherboard equipped with conventional PCI and ISA slots that accommodated the peripherals.

The current version of the Host Controller consists of a **Passive Backplane** that supplies the PCI and ISA slots. A special slot on the Passive Backplane accommodates the **Single Board Computer** (SBC), which performs the same functions as the earlier motherboard, but is easier to troubleshoot and replace.

Please refer to **Section 4 - Host Controller** for more information.

System Interface PCB

The System Interface PCB resides in ISA bus slot 2 of the Host Pentium CPU motherboard. As its name implies, the System Interface PCB helps the Host Pentium Processor communicate with other system devices. Main features of the System Interface PCB include:

- An Option PROM that configures the Host Pentium Processor's BIOS for operation in the Workstation
- An ARCNet Controller and Interlock that enable the Host Pentium Processor to communicate with other intelligent PCBs in the Workstation and in the image generator
- Data bus buffers that develop rewind, fast forward, play, pause, and record signals for the optional video cassette recorder (VCR).
- Serial communication chips that enable the Host Pentium Processor to communicate with the modem, monitors (for setup and automatic contrast/brightness control), Control Panel PCB, and Touch Screen assembly

SCSI Controller PCB

The SCSI Controller PCB located in PCI Bus 0 slot 7 enables the Host Pentium Processor to communicate with several daisy-chained peripherals, including a removable media hard disk drive, CDROM drive, and magneto-optical drive. The principal advantage of using SCSI technology is that one interface can control up to seven devices.

When the Workstation is equipped with an optional Cine Disk subsystem, the SCSI controller PCB connects to the PCI Bus on the Cine Bridge PCB.

Ethernet (DICOM) Interface PCB

The optional 32-bit Ethernet adapter PCB resides in PCI Bus 0 slot 8. The PCB allows the Workstation to transmit images over a local DICOM network. The card can communicate at up to 132 Mb/s with the Pentium PCI motherboard, and at 100 Mb/s over the network.

VGA Video Card

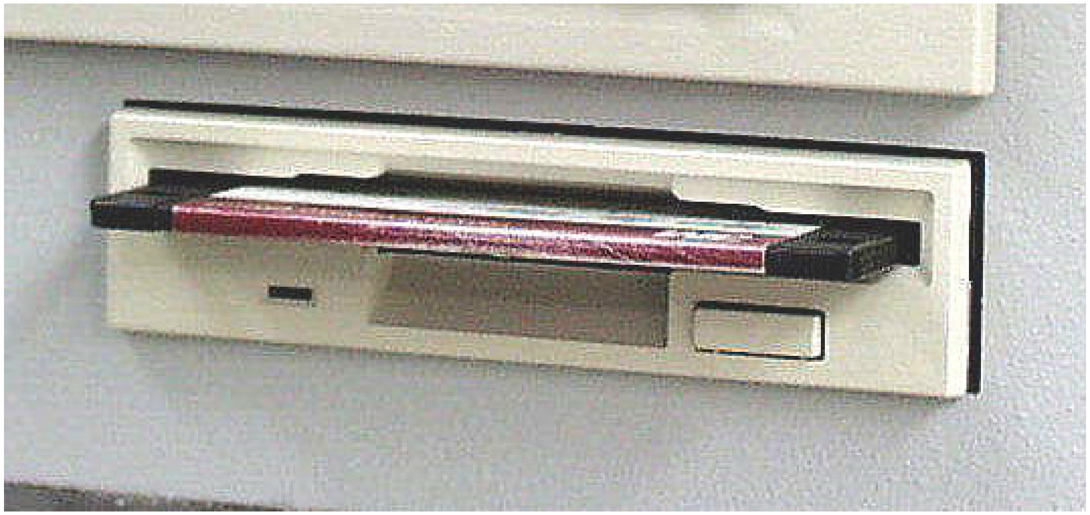
ISA Bus Slot 4 in the Host Pentium CPU motherboard is normally vacant and unused. It can, however, accommodate a VGA video card that may be used for diagnostic purposes.

IDE Hard Disk Drive

The Workstation normally boots from the 50-megabyte non-DOS partition of this 4.3-Gigabyte drive, which contains the Nucleus® operating system and OEC application software. This drive also has a DOS-readable partition that is available to the user for image and data storage. The IDE hard disk drive is located in the bottom right-hand corner of the Electronics box.

Floppy Disk Drive

The 3.5-Inch, 1.44-megabyte floppy disk drive, located on the Workstation rear panel at the rear of the Electronics box, serves as an alternate boot drive; it can also store single images on standard 3.5-inch floppy disks.



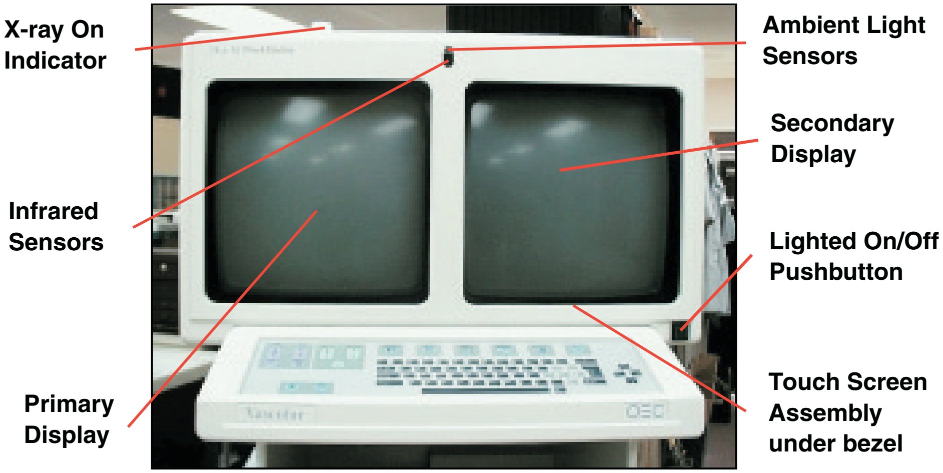
3.5-Inch, 1.44-Megabyte Floppy Disk Drive on Workstation Rear Panel

Display Subsystem

The following is a basic description of the Display Subsystem hardware. Refer to **Section 5 - High Resolution Displays** for detailed circuit descriptions, troubleshooting information, and component replacement instructions.

The Display Subsystem consists of two 16-inch, high resolution, high contrast, high brightness, monochrome monitors. Each monitor can display up to 1030 lines per frame with 1320 pixels per line maximum. The left-hand monitor is called the Primary display because it shows newly acquired images. The right-hand monitor is called the Secondary display; it shows acquired images and provides a mounting place for a Touch Screen assembly that you can use with a CRT-displayed graphical user interface to control many system functions.

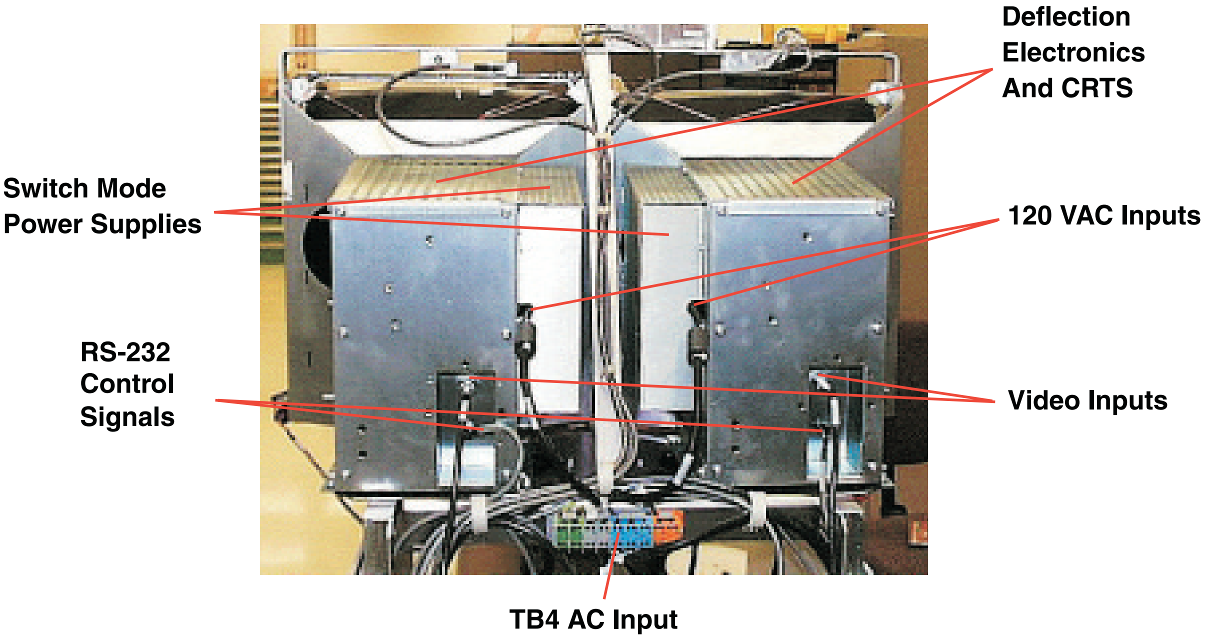
The monitor frame serves as the mounting point for the **X-Ray On indicator**, **infrared remote sensors**, **ambient light sensor**, and the lighted **ON/OFF pushbutton**, which are described elsewhere in this section.


X-ray On Indicator
Infrared Sensors
Primary Display
Ambient Light Sensors
Secondary Display
Lighted On/Off Pushbutton
Touch Screen Assembly under bezel

High Resolution Displays

The following illustration shows a rear view of the two Workstation monitors. Both monitors are electrically identical; each is powered by 120 VAC from TB4, and each receives its video drive signal from the Display Controller PCB. The System Interface PCB supplies control signals from the Host CPU to the monitors. These RS-232 signals control image contrast and brightness, and setup parameters such as vertical size and raster centering.

Mechanically, the Primary and Secondary displays are approximate mirror images of each other. The larger cage on each monitor holds the CRT, deflection electronics, and video circuits. The smaller cage holds the switch mode power supply.

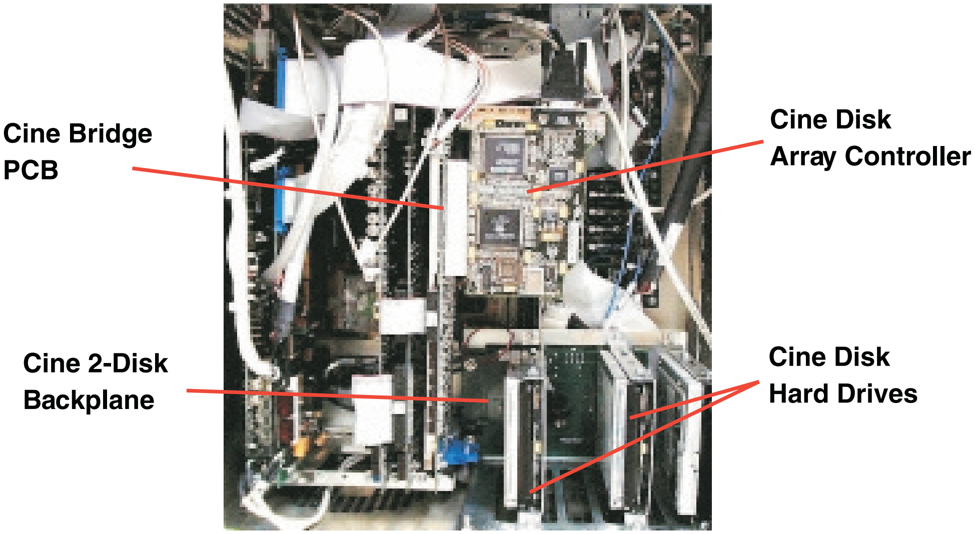

Deflection Electronics And CRTS
Switch Mode Power Supplies
120 VAC Inputs
RS-232 Control Signals
Video Inputs
TB4 AC Input

High Resolution Displays - Rear View

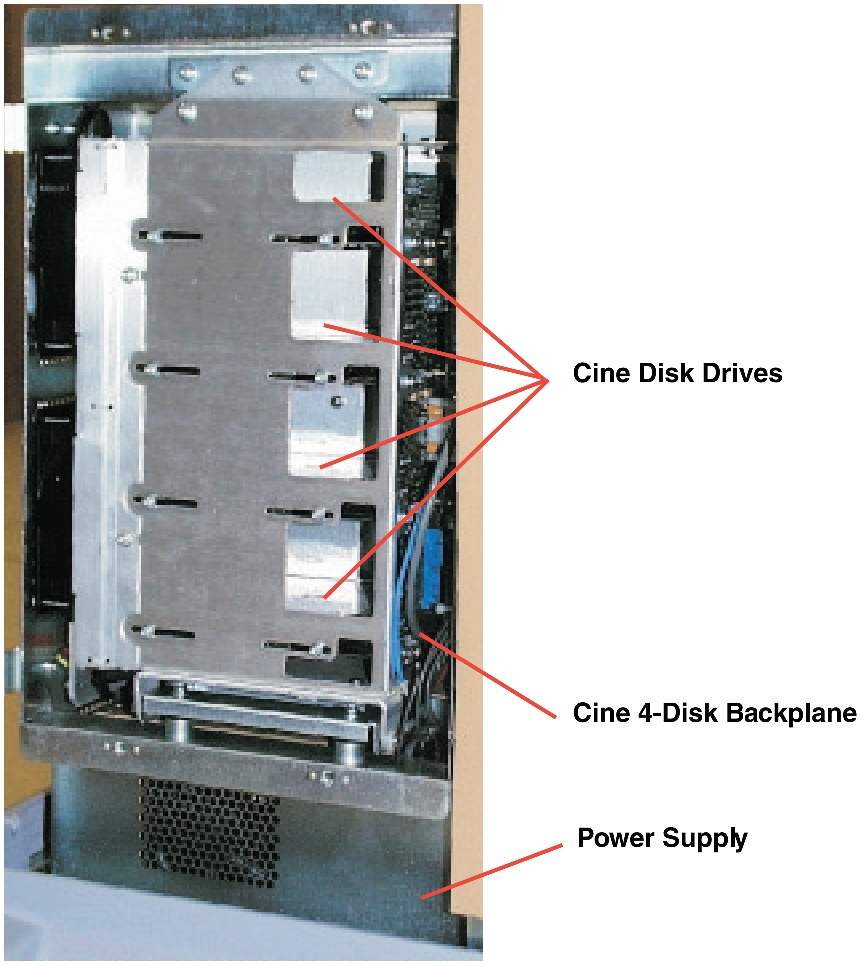
Cine Disk Subsystem

The following is a basic description of the Cine Disk hardware. Refer to **Section 6 - Cine Disk Subsystem** for detailed circuit descriptions, troubleshooting information, and component replacement instructions.

The optional Cine Disk Subsystem allows the Workstation to capture digitized X-Ray images from its Image Subsystem at 15 FPS or 30 FPS (12.5 and 25 FPS at 50 Hz). The Cine Disk Subsystem consists of the Cine Bridge PCB, which mates with a PCI bus slot on the Host Pentium CPU, a Cine Disk array controller that resides on the Cine Bridge PCB or plugs into one of the PCI 1 bus slots on the Cine Bridge PCB, one or two Cine Disk Backplane PCBs, and up to six hard disk drives. The larger four-disk backplane resides in a separate Cine Disk assembly with its own power supply near the Electronics box. The two-disk backplane and associated hard drives mount inside the Electronics box.



Cine Disk Components in Electronics Box


Cine Disk Drives
Cine 4-Disk Backplane
Power Supply

Cine Four-Disk Assembly (Covers Removed)

Cine Bridge PCB

The main purpose of the Cine Bridge PCB is to generate another PCI bus (PCI Bus 1) that is separate but linked to the Host Pentium CPU's PCI Bus (PCI Bus 0). Although the Host Pentium CPU maintains control of PCI Bus 1, it is actually a reserved, high-capacity data path between frame memory on the Cine Bridge PCB and the Cine Disk array. Having a separate PCI bus enables the Host Pentium CPU to maintain its full PCI bandwidth while images transfer at required speed to and from the Cine Disk drives.

The Cine Bridge PCB accepts X-Ray image data from the Image Processor as 10-bits-per-pixel parallel data. During image acquire mode, the Cine Bridge PCB packs three pixels into a single 32-bit word and stores the packed image in one of three frame buffers. During image playback, frame data from the disk drives fill one buffer while a pixel packer unpacks a different buffer. The Cine Bridge PCB returns image data to the Image Processor in the 10-bit-per-pixel parallel format.

Cine Disk Array Controller

The cine disk array controller is also known as the Fibre Channel Arbitrated Loop (FC-AL) Disk Controller. It provides the data interface between the Cine Bridge PCB and the cine disk drives. The controller's job is to exchange image data with the frame buffers on the Cine Bridge PCB and the Cine Disk drives.

The FC-AL serial data loop daisy-chains to each drive, starting at the controller and returning there after passing through the backplanes. Loop data leaves the controller on fibre channel cable and arrives at the Two-Disk Backplane, where it enters the first disk drive and then the second disk drive on the backplane. The output of the Two-Disk Backplane feeds the input of the Four-Disk Backplane, again on fibre channel cable. After passing serially through each drive on the Four-Disk Backplane, the 1.063 Gb/s loop data returns to the controller, once more on fibre channel cable.

CAUTION: *Fibre channel cable is very fragile. If the foam core supporting either conductor is kinked or pinched, an impedance "bump" occurs at that point, attenuating the high rate FC-AL signal and sometimes causing data loss. Never compress a fibre channel cable or bend it with a radius of less than 0.5 inches.*

Cine Disk Backplanes

Each Cine Disk Backplane performs several functions:

- Provides power to each disk drive
- Provides looping input and output FC-AL fibre channel connectors
- Provides loop resiliency circuits (LRCs) that detect whether drives are plugged in and route the FC-AL signal past missing or inoperative drives

Cine Hard Disk Drives

The Cine Disk drives are much like standard SCSI drives, except that they contain circuitry that unpacketizes incoming commands and data into normal SCSI format, and packetizes outgoing SCSI data for transmission over the FC-AL loop.

Image Subsystem

The following is a basic description of the Image Subsystem hardware. Refer to **Section 7 - Image Subsystem** for detailed circuit descriptions, troubleshooting information, and component replacement instructions.

The Image Subsystem processes video from the CCD camera to produce enhanced images for the Display system monitors and Cine Disk subsystem. The Image Subsystem also produces standard resolution interlaced video for the optional VCR, and digitized images for the DICOM interface, optional laser camera, and optional hardcopy devices. The Image Subsystem includes the Video Controller PCB, Image Processor PCB, and Display Adapter PCB, all of which are located in the Workstation's Electronics box.

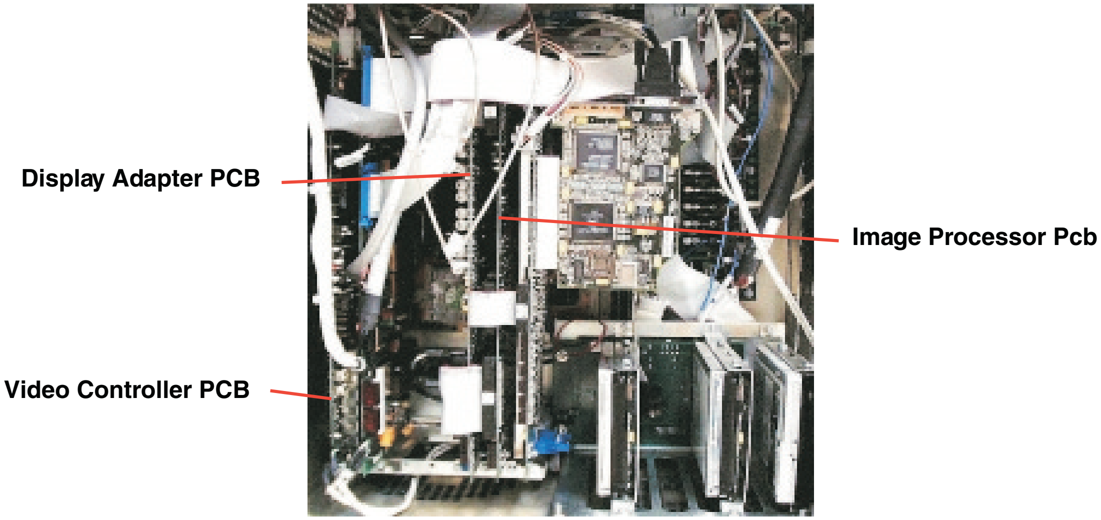


Image Subsystem Components in Electronics Box

Video Controller

The Video Controller accepts analog differential video and pilot tone (sync) signals from the CCD camera. The pilot tone signal contains sync, drive, and pixel clock data. The Video Controller converts the analog video signal to ten bits per pixel parallel data, which it sends to the Image Processor.

The Video Controller performs Genlock control for the Workstation, anti-aliasing and anti-vignetting of the digital X-Ray images, and creates the VLI window needed for the X-Ray Generator to perform Automatic Brightness Stabilization.

Image Processor

As its name implies, the Image Processor manipulates the digital video from the Video Controller to produce the following effects and functions in the displayed images:

- Vertical and horizontal image reversal
- Circular blanking
- Window and level control
- Automatic sample window positioning
- Real-time image edge enhancement
- Subtraction
- Peak opacification
- Zoom and roam
- Cine interface generation
- Text and graphics for image annotation

Display Adapter

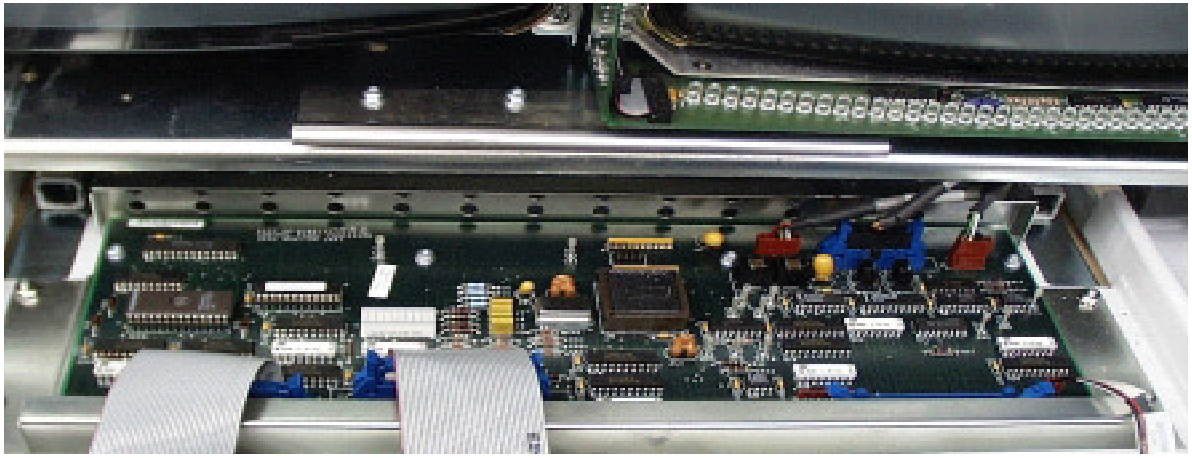
The Display Adapter PCB translates the 25 or 30 FPS 1024 x 1024 pixel images generated in the Image Processor to 60 or 75 FPS non-interlaced video for output to the high-resolution display monitors. The Display Adapter also converts the non-interlaced Image Processor video to standard resolution interlaced video that is compatible with PAL or NTSC video cassette recorders and monitors.

User Interfaces

The Workstation’s user interface includes the Control Panel Processor (a PCB that mounts below the Keyboard), Keyboard, Infrared Receiver and Handheld Transmitter, Touch Screen, XRAY ON indicator, and ON/OFF pushbutton. Refer to **Section 8 - User Interface** for detailed circuit descriptions, troubleshooting information, and component replacement instructions.

Control Panel Processor

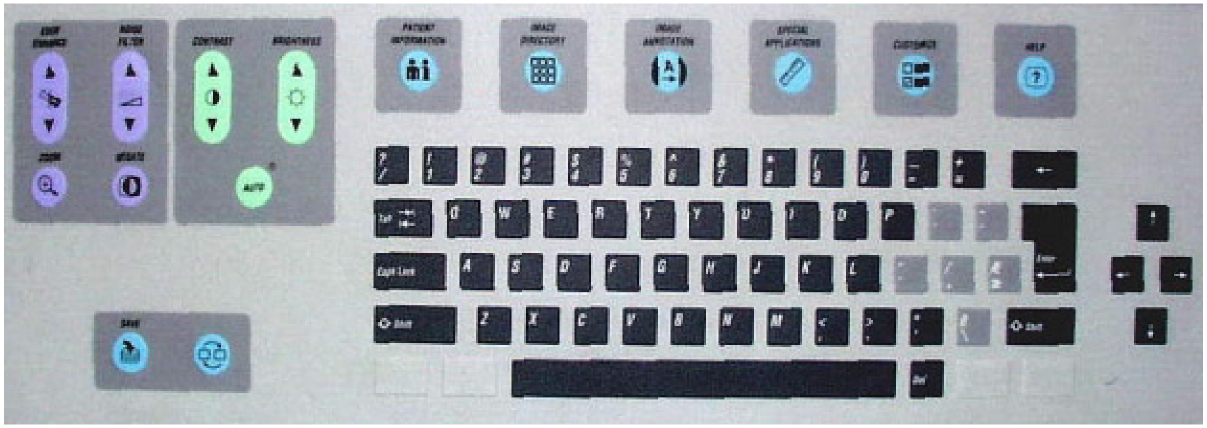
The Control Panel Processor (CPP) scans for key closures on the Keyboard and reports these closures to the System Interface PCB in the Host Controller subsystem for further processing. The CPP also responds to commands from the System Interface PCB to light Keyboard LEDs.



Control Panel Processor

Keyboard

The operator uses the keyboard to enter patient annotation information and control system operation. The keyboard has a standard QWERTY alphanumeric key array, plus several special-purpose keys. It is covered by a flexible membrane designed to resist liquids and other contaminants, and is replaceable (but not repairable) in the field. The keyboard PCB has no active circuitry; its keys are scanned by the Control Panel Processor, which also drives the LEDs on the keyboard PCB.

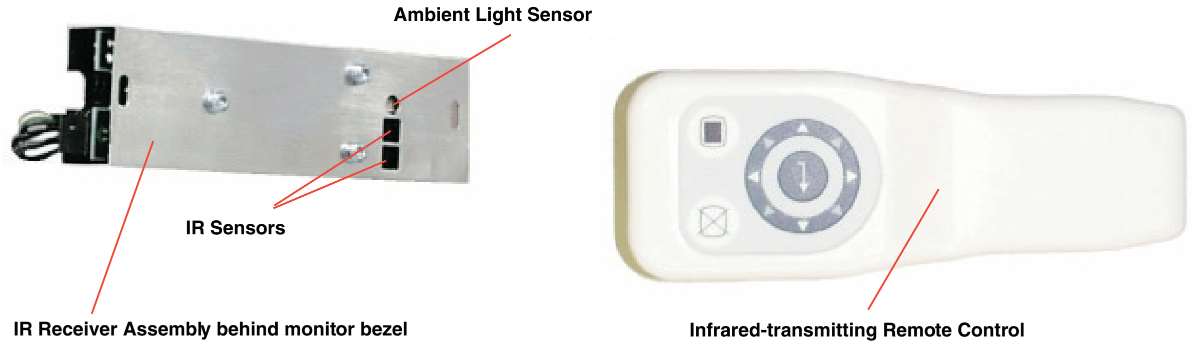

EDGE ENHANCE
NOISE FILTER
CONTRAST
BRIGHTNESS
PATIENT INFORMATION
IMAGE DIRECTORY
IMAGE ANNOTATION
SPECIAL APPLICATIONS
CUSTOMIZE
HELP
ZOOM
AUTO
SAVE
Enter
Shift
Caps Lock
Tab
Del

Keyboard

Infrared Remote

The optional infrared (IR) remote system consists of a battery-operated, hand-held IR transmitter, and an IR receiver that mounts between the two Workstation monitors behind the bezel. You can use the hand-held transmitter up to 20 feet from the Workstation to access most system functions. When you press a button on the hand-held IR transmitter, the transmitter generates a pulsed waveform and converts it to invisible infrared light, much like a standard television remote control. The IR receiver assembly in the Workstation detects the IR beam from the transmitter, converts the pulsed infrared light back to an electronic signal, and passes the signal to the Control Panel Processor for decoding and processing.

The ambient light sensor is part of the high-resolution **Display Subsystem**. It senses room lighting conditions, enabling the display subsystem to maintain proper monitor brightness.

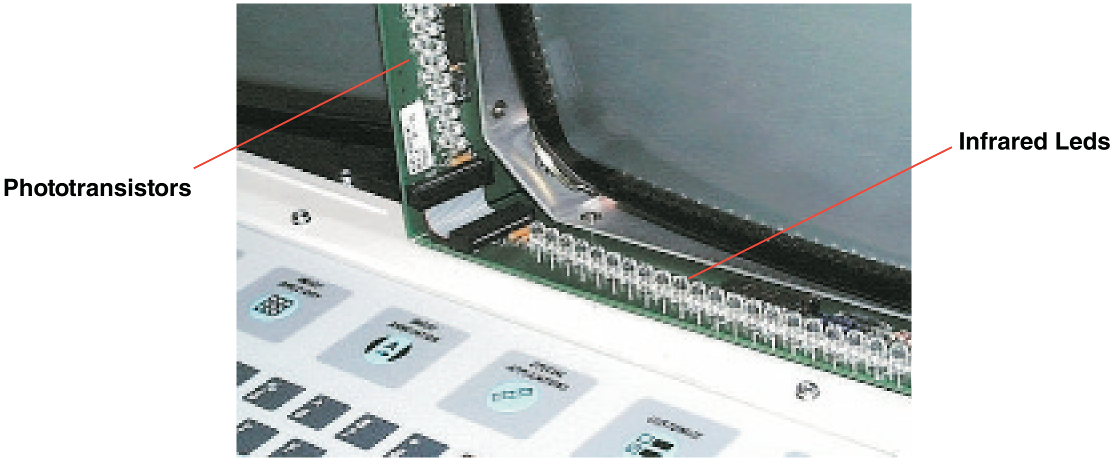

Ambient Light Sensor
IR Sensors
IR Receiver Assembly behind monitor bezel
Infrared-transmitting Remote Control

IR Receiver and Hand-held Remote Control

Touch Screen

The Secondary system display (i.e., the right-hand monitor) is equipped with an array of infrared light-emitting diodes and a corresponding array of phototransistors that detects the presence and calculates the location of a finger touched to the CRT. You use this touch screen feature in conjunction with displayed software screens to make mode and function selections during Workstation operation.

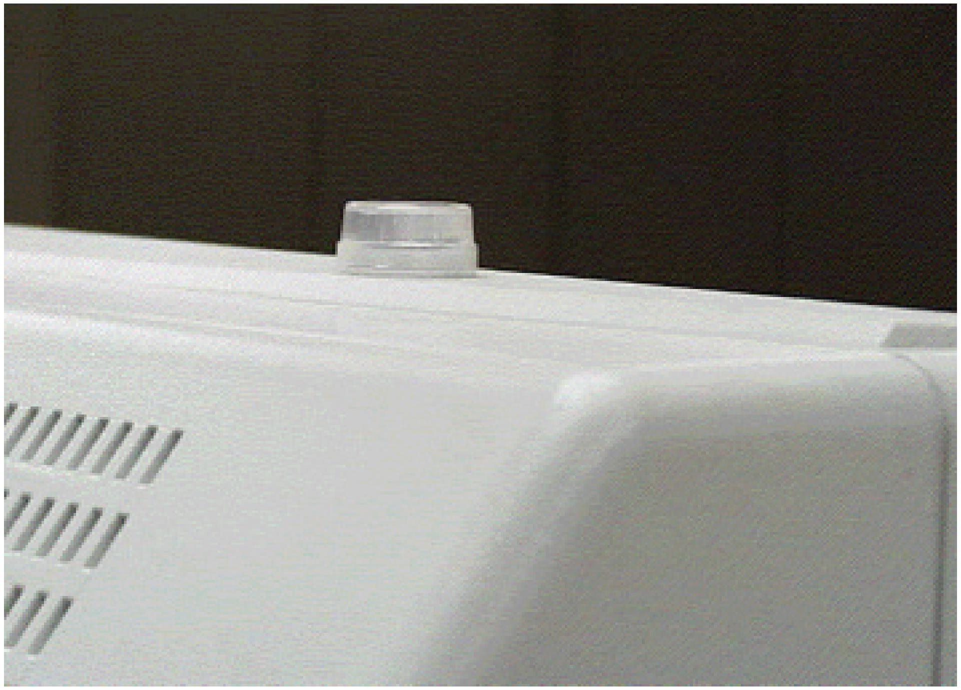
The LEDs and phototransistors are arranged in a rectangular matrix on a touch frame that surrounds the edge of the CRT. These devices are ordinarily invisible behind the monitor bezel. The touch frame has 43 LEDs on the right-hand edge, 43 LEDs on the bottom edge, 43 phototransistors on the top edge, and 43 phototransistors on the left-hand edge. A simple controller associated with the touch screen scans each phototransistor several times a second to detect beam interruptions, determines the x and y coordinates for the beam interruption, and transmits that information via RS-232 interface to the System Interface PCB for further processing.



Touch Screen Assembly

X-RAY ON Indicator

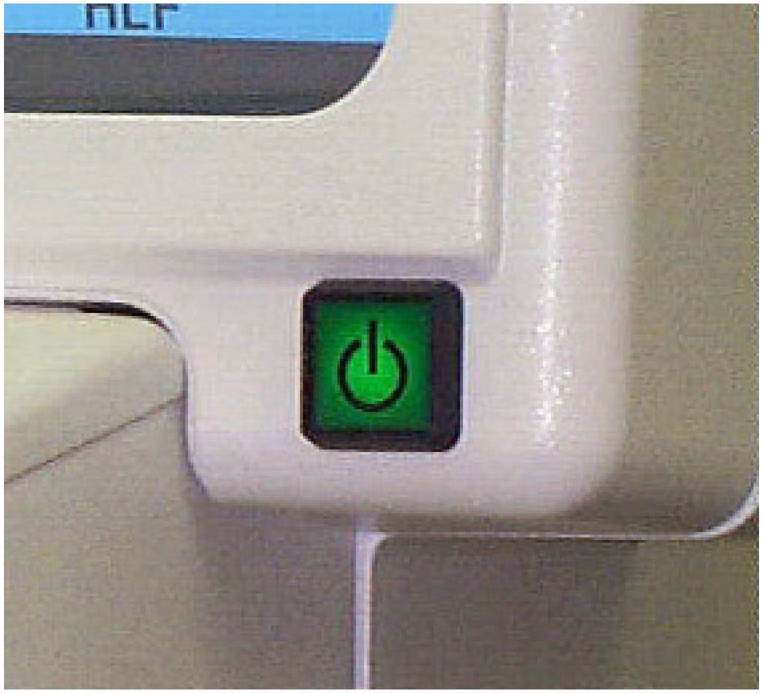
The X-RAY ON indicator lights at any time the system generates X-rays. Located on the top of the left-hand monitor, the indicator contains an array of six LEDs driven by a signal from the System Interface PCB.



X-Ray On Indicator

Lighted ON/OFF Pushbutton

The lighted SPST ON/OFF pushbutton controls application of AC power to the Workstation. The switch's 12-volt incandescent bulb lights when the Workstation is on.



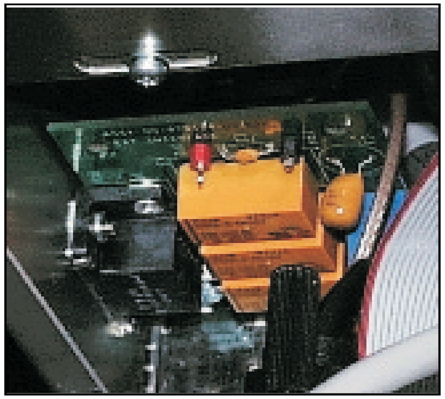
ON/OFF Pushbutton

External Interfaces

This paragraph discusses the External Interface PCB and Workstation rear panel. Refer to **Section 9 - External Interfaces** for detailed circuit descriptions, troubleshooting information, and component replacement instructions.

External Interface PCB

The External Interface PCB connects via ribbon cable to the System Interface PCB, which connects to ISA slot 2 on the Host Pentium CPU motherboard located in the **Electronics box**. As its name implies, the External Interface PCB connects the motherboard to the outside world. It provides DC isolation where necessary and adapts system signals to make them compatible with external equipment connected to the Workstation rear panel and Interconnect cable. In some cases, the External Interface PCB passes signals straight through without modification. In other cases it adds a simple pullup resistor or current-limiting resistor to a signal line. In other cases, the External Interface PCB uses an ISA bus signal to switch relay contacts. The External Interface PCB mounts directly behind the Workstation rear panel as shown below.



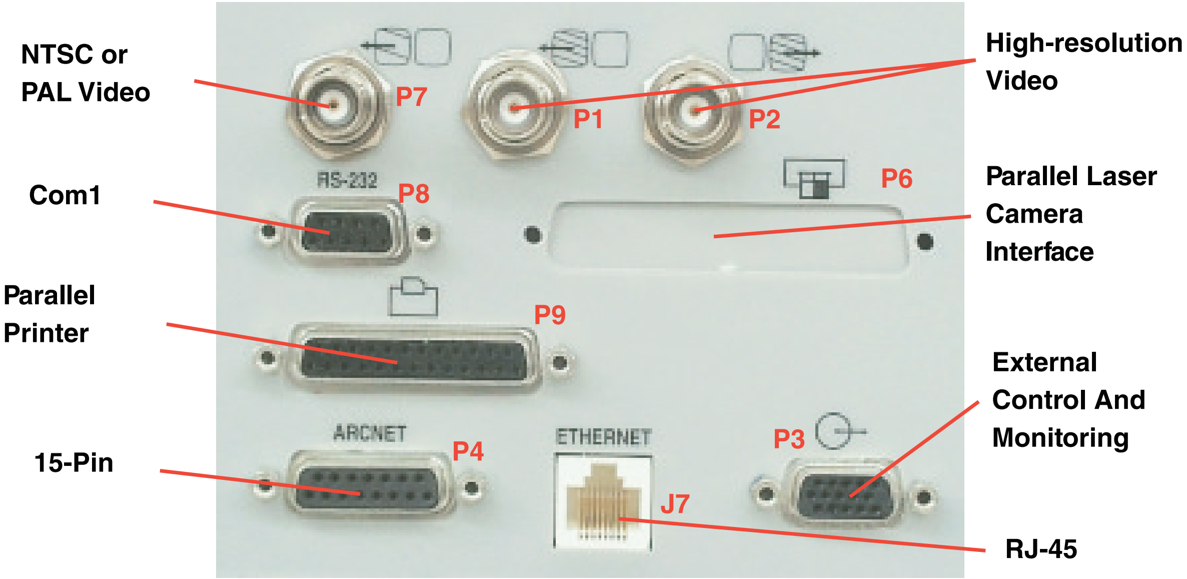
View inside electronics box directly behind rear panel connectors

External Interface PCB

Rear Panel Connectors

The following illustration shows the Workstation rear panel connectors.

Not all interfaces present on the Workstation rear panel pass through the External Interface PCB. For example, COM1 and LPT1 connect directly to the Host Pentium CPU, and the video signals come directly from the Display Controller.


NTSC or PAL Video
P7
P1
P2
High-resolution Video
Com1
RS-232
P8
P6
Parallel Laser Camera Interface
Parallel Printer
P9
External Control And Monitoring
15-Pin
ARCNET
P4
ETHERNET
J7
P3
RJ-45

Workstation Rear Panel Connectors

Power Distribution Subsystem

The Workstation Power Subsystem distributes AC and DC power to Workstation components, and may also provide AC power to externally attached equipment such as a C-Arm. Power Subsystem components include the power plug and cord, Surge Suppressor PCB, Isolation Transformer, AC circuit breakers, Power Control PCB, terminal blocks, AC line filter, cooling fans, and DC power supplies PS1 and PS2. These components are located throughout the Workstation. Refer to **Section 3 - System Power Distribution** for additional information.

System Software

System software that controls both the Workstation and the X-Ray generator resides on the Workstation’s IDE Hard Disk Drive. The Workstation Host Controller subsystem normally boots from this drive.

OEC application software executes under the Nucleus® operating system. The OEC applications and operating system are both located in the non-DOS formatted 50 Mb portion of the hard drive.

File management and related utilities are located on the DOS-formatted section of the hard drive.

Boot Sequence

When you power up the Workstation, Host CPU software begins a step-by-step process of conducting power-on self tests (POSTs), establishing ARCnet interprocessor communications, and performing other tasks that prepare the system for use. This series of events is called the boot sequence. For a detailed description of the steps included in the boot sequence, refer to **Section 10 - Software**.

Status and Error Codes

If an error occurs during the boot-up process, an error message appears on the right-hand display. Refer to **Section 10 - Software** for a complete description of each status and error code.

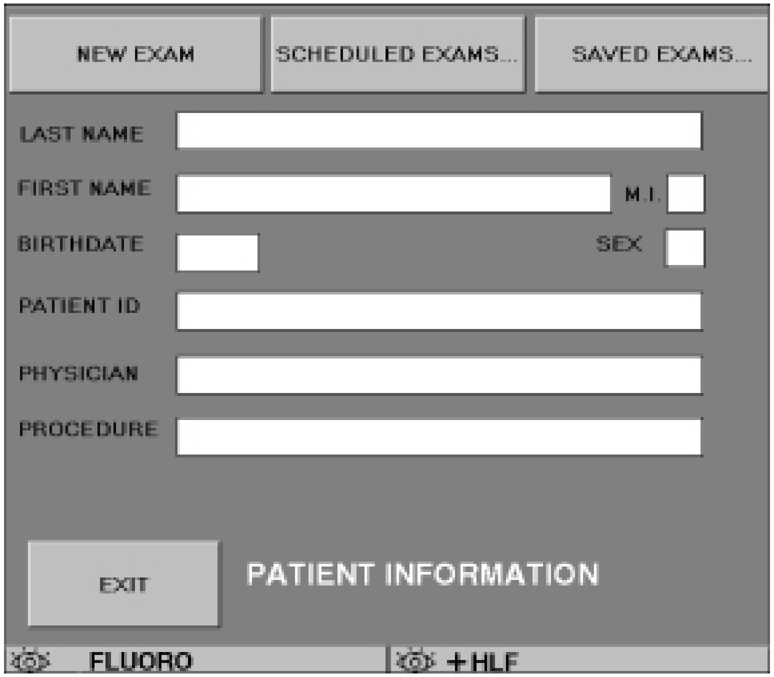
Run-time Error Reporting

Errors that occur during Workstation operation generate a message on the right-hand display and cause the Workstation software to cease operation. Run-time errors include DOS errors, I/O errors, critical errors, and fatal errors. For a description of the run-time errors most likely to affect Workstation operation, refer to **Section 10 - Software**.

Touch Screen Graphical Interface

Workstation software includes a comprehensive graphical user interface (GUI) that works with the **Touch Screen** hardware described above to allow you to select modes and features by touching a finger to the right-hand display screen.

The Patient Information screen, shown below, appears automatically after a successful Workstation boot-up.


NEW EXAM
SCHEDULED EXAMS...
SAVED EXAMS...
LAST NAME
FIRST NAME
M.I.
BIRTHDATE
SEX
PATIENT ID
PHYSICIAN
PROCEDURE
EXIT
PATIENT INFORMATION
FLUORO
+HLF

Patient Information Screen

The Patient Information screen gives you four choices:

1. Touch **NEW EXAM** to enter information for a new patient.
2. Touch **SCHEDULED EXAMS** to display a list of patients who have not yet been examined.
3. Touch **SAVED EXAMS** to display a list of patients for whom images have been stored.
4. Touch **EXIT** to go to the Main Image screen

Each of the above choices displays another unique touch screen that requires further operator input. Nearly all system functions are available through the touch screen interface.

Please refer to the **OEC Workstation Operator's Guide** for complete information on how to use the Touch Screen interface. This is a paper document supplied with the Workstation.

Setup Utilities

The Host CPU motherboard has flash ROM BIOS that is preconfigured by OEC at the factory for the specific equipment and options supplied with each Workstation. When you add or replace Workstation equipment, follow the instructions you receive from the factory to update the BIOS.

Service Port

The ARCNET connector on the Workstation rear panel is a secure serial port reserved for customer technical personnel or OEC Field Service Engineers. It is used to configure, test and calibrate both the Workstation and X-Ray generator.

The service port uses a packet-based handshaking protocol to communicate with a remote computer. Usually the remote computer will be a laptop located a few feet away from the Workstation.

The remote computer becomes the server, downloading command and data packets to the Workstation client. The Workstation responds with an ACK when it successfully receives a packet, and with a NAK if it doesn’t receive a complete packet within the timeout period. The remote computer resends the packet until it receives an ACK from the Workstation, and then sends the next packet. An upload from the client (the Workstation) consists of much the same protocol in reverse; the Workstation sends a packet, which the remote computer responds to with an ACK or NAK. In the event of a NAK, the Workstation resends the packet until its service port times out. A timeout of the service port terminates the remote session.

Refer to **Section 9 - External Interfaces** for complete hardware information on the Workstation’s service port.

Remote Utilities

The Remote Utilities Software (RUT) is a suite of programs that execute on a remote computer, which communicates with the Workstation service port just described. RUT allows customer technical personnel and OEC Field Service Engineers access to the system for the following purposes:

- Setup
- Configuration
- Calibration
- Troubleshooting

Please refer to **Section 10 - Software** for additional details on the Remote Utilities.

Modes of Operation

The following paragraphs describe the six basic modes of operation for the OEC Workstation, including Fluoro, High-Level Fluoro, Digital Spot, Subtract, Roadmap, and Film. Only basic descriptions of these modes will be given here. For a complete description of how to enter and use each mode, refer to the **OEC Mobile Workstation Operator's Guide.** This is a paper manual that ships with the Workstation.

Fluoro

During Fluoro (fluoroscopic) mode, the Workstation displays live X-Ray images on the left-hand monitor (also known as the Primary Display). Technique (kVp and mA) control can be manual or automatic. A fluoro shot terminates and image acquisition ceases when the operator releases the X-Ray switch.

High-Level Fluoro

During High-Level Fluoro (HLF), fluoroscopic mA increases to reduce noise and improve image quality. The Workstation displays live X-Ray images on the left-hand monitor (Primary Display). Technique control (kVp and mA) can be manual or automatic. A high-level fluoro shot terminates and image acquisition ceases when the operator releases the X-Ray switch, or when the length of the exposure reaches a preset amount of time (20 seconds maximum).

Digital Spot

The Digital Spot mode creates short-duration HLF images to visualize dense anatomy. The Workstation automatically saves the image to the hard disk after each exposure. After you save the image to disk, you can apply image enhancements such as Noise Reduction, Sharpen, or Contrast/Brightness.

Subtract

Subtraction produces images that are the difference between a fluoroscopic image obtained while contrast media is present in a vessel and a mask image of the same anatomy obtained just prior to the subtraction process before injection of the contrast media. The subtracted image appears on the left-hand monitor. Subtraction is ideal for visualizing vasculature.

Roadmap

Roadmapping produces a series of subtracted images that are the difference between a fluoroscopic image obtained with a catheter present in a vessel, and a mask image obtained just prior to catheter insertion when a peak level of contrast media is present in the vessel. Roadmap images appear on the left-hand monitor. Because they clearly show catheter movement, Roadmap images are very useful in precise catheter placement.

Film

The Film mode automatically produces the correct technique to expose radiographic film.

Configurations

The Workstation is available in five basic configurations: Enhanced Surgical Platform (ESP), Enhanced Surgical Platform - Cine, Vascular, Neurovascular, and Cardiac.

Enhanced Surgical Platform

The Enhanced Surgical Platform (ESP) is the basic Workstation configuration around which the other Workstation configurations are built. The ESP includes the following features:

- Standardized, sealed keyboard
- Touch screen graphical user interface (GUI)
- Expanded external interface capabilities
- DICOM interface

When all options are installed, the ESP has the following capabilities:

- On-line help screens for system functions and features
- Image annotation
- Image directory that allows image selection by doctor, patient, or date
- Display of X-Ray dose information that includes shot type, date, time, mode, DAP, cumulative DAP, and technique
- Dose Log option that displays DAP, cumulative DAP, and modes used. Dose measurement may be set to microgray or rad
- Access special applications such as vessel measurement software
- Test pattern screen
- Customization screen for Auto Save and other functions

- Entry of date and time
- A VCR interface that allows images to be recorded to and played back from S-VHS cassette tape
- Zoom in and roam a region of interest on recorded images.
- Provide edge enhancement on LMON images
- Apply variable sharpening on static and real-time images
- Reverse image grayscale to represent a film negative
- Provide autohistogram image equalization
- Provide automatic and manual brightness and contrast control
- Provide mode selection interface to X-Ray generator that allows selection of fluoro and digital spot modes
- Apply noise filter (recursive averaging) to 2, 4, 8, or 16 frames
- Save any LMON image to hard disk
- Swap images between monitors
- Control cursor movement and mode selection with keyboard, touch screen GUI, or IR remote

Enhanced Surgical Platform -- Cine

This Workstation configuration includes the features and capabilities of the ESP Workstation described above, plus the ability to record images at 15 FPS (12.5 FPS at 50 Hz) for up to 5 minutes. The ESP has no digital subtraction or roadmapping capability.

Vascular

The Vascular Workstation has the same features as the ESP - Cine Workstation described above, plus the ability to perform digital subtraction and roadmapping. The Vascular Workstation also offers the Landmark feature that displays a variable percentage of background in a subtracted image, Mask Registration to realign a mask with a subtracted image, and Peak Opacification to improve the contrast of a subtracted image.

Neurovascular

The Neurovascular Workstation is similar to the Vascular Workstation, except that it has 30 FPS, 5-minute Cine capability. High-Level fluoro and the 30 PPS option are not available. The removable zip disk is an option.

Cardiac

The Cardiac Workstation offers 30 FPS, 5 minute Cine Disk capability, High-Level fluoro, and the removable zip disk as standard features. The 30 PPS option is also available in the Cardiac Workstation.

Options

The following optional equipment is available for the OEC Workstation.

Cine Disk

The Digital Cine option offers high technique levels for imaging small vessels and other anatomy that is in constant movement. The 15 FPS option stores high resolution images at up to 15 images per second (12.5 FPS at 50 Hz) for up to five minutes. The 30 FPS option stores images at up to 30 images per second (25 FPS at 50 Hz) for up to five minutes.

For more information, refer to **CINE DISK SUBSYSTEM**, which appears earlier in this section, or to **Section 6 - Cine Disk Subsystem**.

Measurement Software

This optional software feature allows a doctor to make linear or angular measurements of vessels, bones, and other anatomy. It is especially useful in orthopaedic and cardiac applications. For additional information the measurement software, refer to **Section 10 - Software**

Infrared Remote

The optional handheld infrared remote control is described and illustrated under **USER INTERFACES,** which appears earlier in this section. The infrared remote is available for all Workstation configurations.

Video Cassette Recorder

The VCR option includes a remotely-controlled, half-inch S-VHS tape machine and the power, control, and signal cables necessary to install the VCR in the Workstation. The VCR accepts down-scanned video from the Display Controller PCB in NTSC (RS-170) or PAL (CCIR) format. Although the VCR cannot record 1kx1k high resolution images, it offers much greater image storage capacity than a cine disk (two hours or more compared to five minutes maximum).

For a complete description of the VCR's video and control interfaces, refer to **Section 7 - Image Subsystem**

SONY
S-VHS HI-FI
EJECT
REC
STOP
REW
PLAY
F FWD
PAUSE
POWER

Video Cassette Recorder

SCSI Devices

The SCSI Controller PCB described previously in the **HOST CONTROLLER** paragraphs supports several optional devices, such as a removable media hard disk drive. The SCSI controller can support up to seven SCSI devices.

Removable Dynamic Digital Disk

The removable disk drive, located on the Workstation rear panel, is supplied as a standard feature on Cardiac Workstations, and is available as an option on others. The removable cartridge can hold about two gigabytes of data. The fast transfer rate and large storage capacity make it ideal for archiving cine runs.

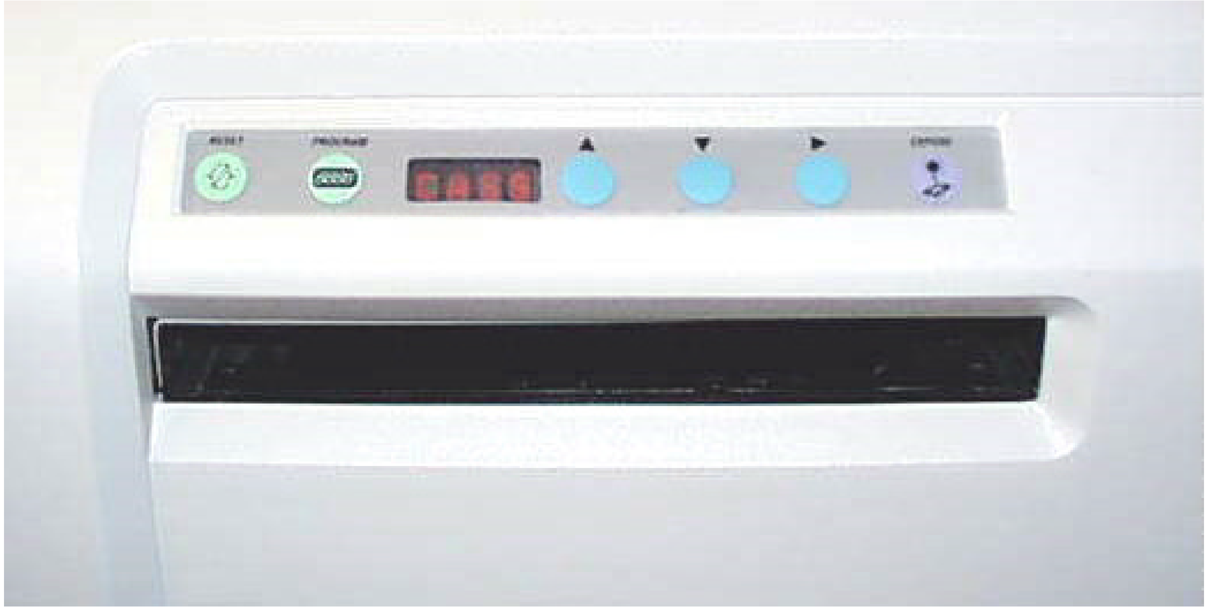
iomega jaz 2GB

Removable Media Hard Disk Drive

Hardcopy Camera

The hardcopy camera prints archived images on standard 8 x 10 inch X-Ray sheet film. It accepts IEEE 1284 compliant digital video from the Display Controller on a 25-pin D-type connector. It prints one or two images on each film sheet under program control.

For complete information on the hardcopy camera interface, refer to **Section 7 - Image Subsystem**.

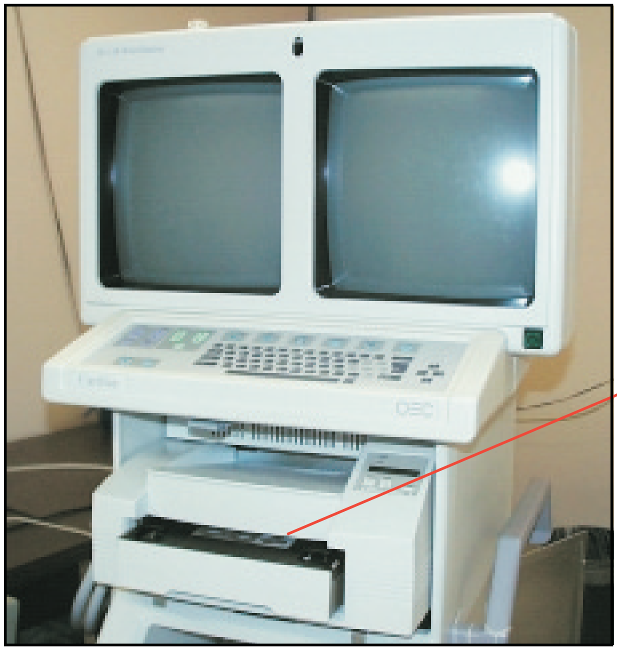


Hardcopy Camera

Instant Film/Paper Printer

The Instant Film/Paper Printer is a hardcopy output device that prints archived images on paper or transparency film at 300 dpi. The printer outputs 256 levels of grey. The printer accepts Centronics-compatible data from the Display controller on a 36-pin connector, and operates under program or front panel control.

For complete information on the Instant Film/Paper Printer interface, refer to **Section 7 - Image Subsystem**.



Mounts on extendable rack under keyboard

Instant Film/Paper Printer

Laser Camera Interface

The laser camera interface is an 8-bit ISA PCB that mounts in ISA slot 3 of the Host Pentium CPU motherboard. Under program control, this PCB transmits digital archived images over a 37-pin D-type connector to a remote laser imaging camera connected to the Workstation rear panel. The laser camera interface supports both the 3M MMU910 and Kodak Model 100 digital interface protocols.

For complete information on the laser camera interface, refer to **Section 7 - Image Subsystem**.

Laser Camera Interface

Thermal Printer

The thermal printer is a hardcopy device that accepts composite video (RS-170 or CCIR) from the Display Controller PCB to produce grayscale images on heat-sensitive paper. Image resolution is typically 256 scales of gray, with 1280 dots per line. The thermal printer requires manual control from a footswitch, remote control unit, or front panel controls. It can print a page in 10 seconds.

For a complete description of the composite video signals produced by the Display Controller, refer to **Section 7 - Image Subsystem**.

Typical Thermal Printer

DC Power Distribution

Circuit/Mechanical Descriptions **2**
  PS1 Output 2
    +5VDC Output 2
    +12VDC Output 6
    ±15VDC Output 7
  PS2 Output 8
  PS3 Output 10
Functional Tests **11**
Fault Isolation **12**
Adjustment **13**
Miscellaneous **13**

Circuit/Mechanical Descriptions

This section applies to the outputs of PS1, PS2, and PS3 power supplies. When you turn on the Workstation, AC operating power and KEY POWER control power combine to energize these power supplies.

PS1 Output

The J1 connector outputs of PS1 are 3 lines of +5VDC, 1 line of+12VDC, 1 line of –15VDC, and 1 line of +15VDC, as shown in the following subsections.

+5VDC Output

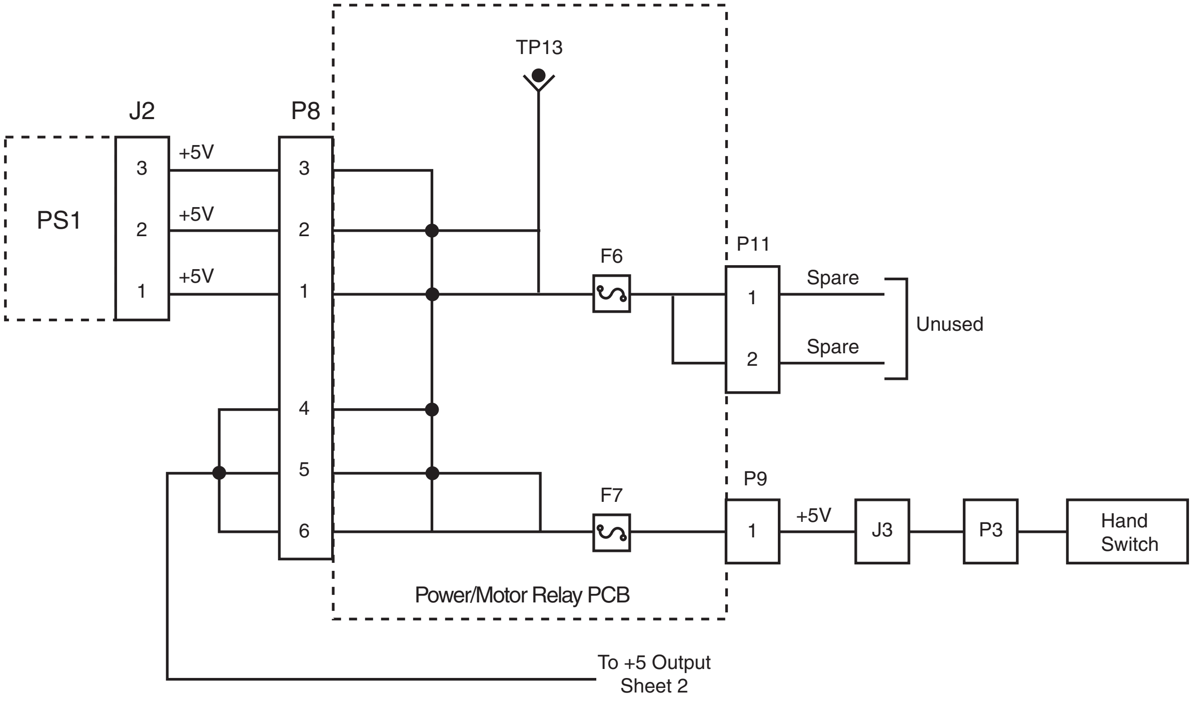
For an illustration of the PS1 +5VDC output, refer to the following diagram:

All 3 lines of the+5VDC outputs connect to the Power/Motor Relay PCB at P8. On the PCB, Fuse F6 protects an unused pair of outputs on Connector P11. F7 protects one line outputting on Connector P9, leading to the Hand Switch.

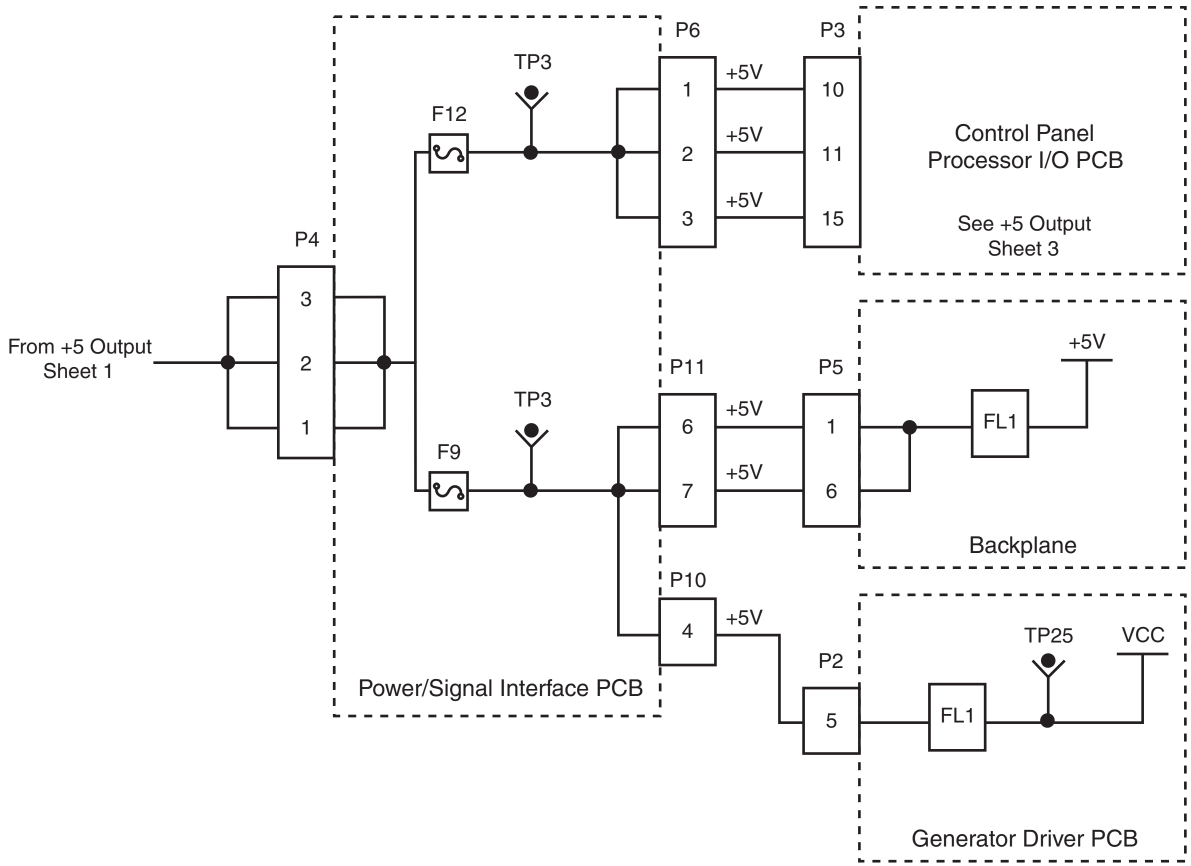
Three additional outputs from the Power/Motor Relay PCB are provided on Connector P8; all three lead to P4 of the Power/Signal Interface PCB. P4 provides paths to two fuses, F9 and F12.

Through F9, +5VDC passes to the Backplane and the Generator Driver PCB. On the Backplane, the +5VDC is used by the three PCBs that sit on it---Fluoro Functions, X-Ray Controller, and HV Supply Regulator. The +5VDC going to the Generator Driver PCB becomes the reference voltage for the board.

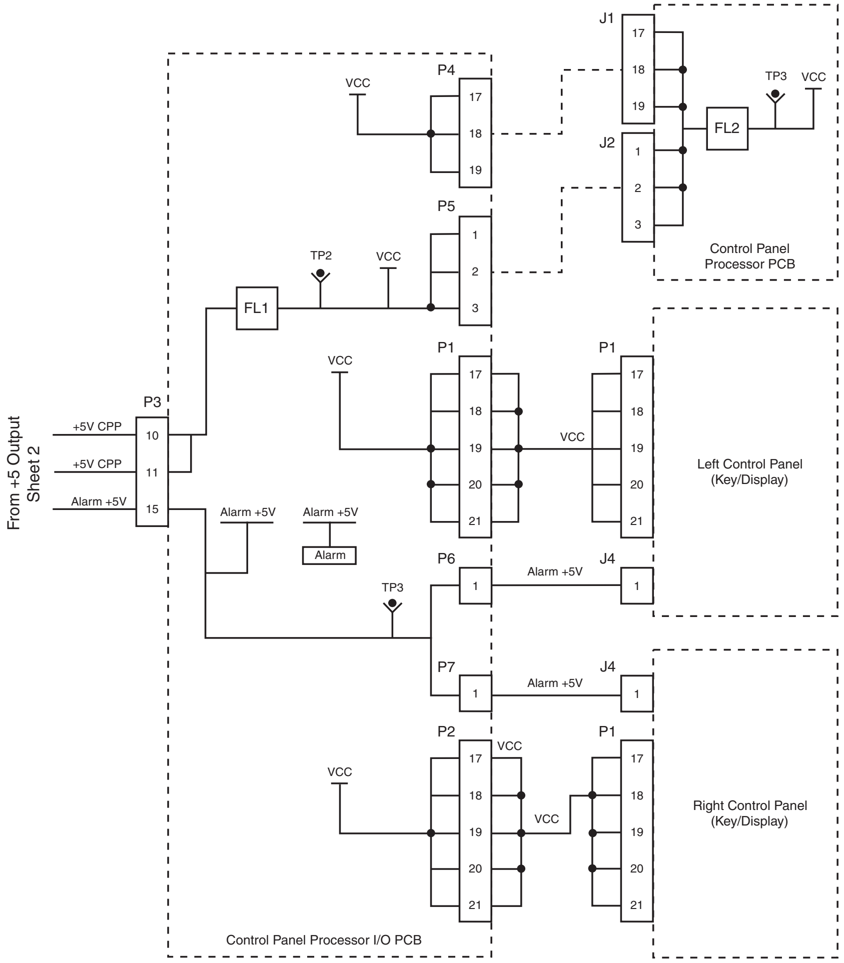
Through F12, +5VDC passes to the Control Panel Processor I/O PCB, where it is used as reference voltage for the board (VCC), and also for alarm circuitry (ALARM +5V). Both are then provided to the Control Panels and the Control Panel Processor PCB.


TP13
J2
P8
PS1
3
2
1
+5V
+5V
+5V
3
2
1
4
5
6
F6
P11
1
2
Spare
Spare
Unused
F7
P9
1
+5V
J3
P3
Hand Switch
Power/Motor Relay PCB
To +5 Output Sheet 2

PS1 +5VDC Output (sheet 1 of 3)


P6
P3
TP3
+5V
1
10
F12
+5V
2
11
Control Panel
Processor I/O PCB
+5V
3
15
See +5 Output
Sheet 3
P4
3
From +5 Output
Sheet 1
2
+5V
1
P11
P5
TP3
+5V
6
1
FL1
F9
+5V
7
6
Backplane
P10
+5V
4
TP25
VCC
P2
FL1
5
Power/Signal Interface PCB
Generator Driver PCB

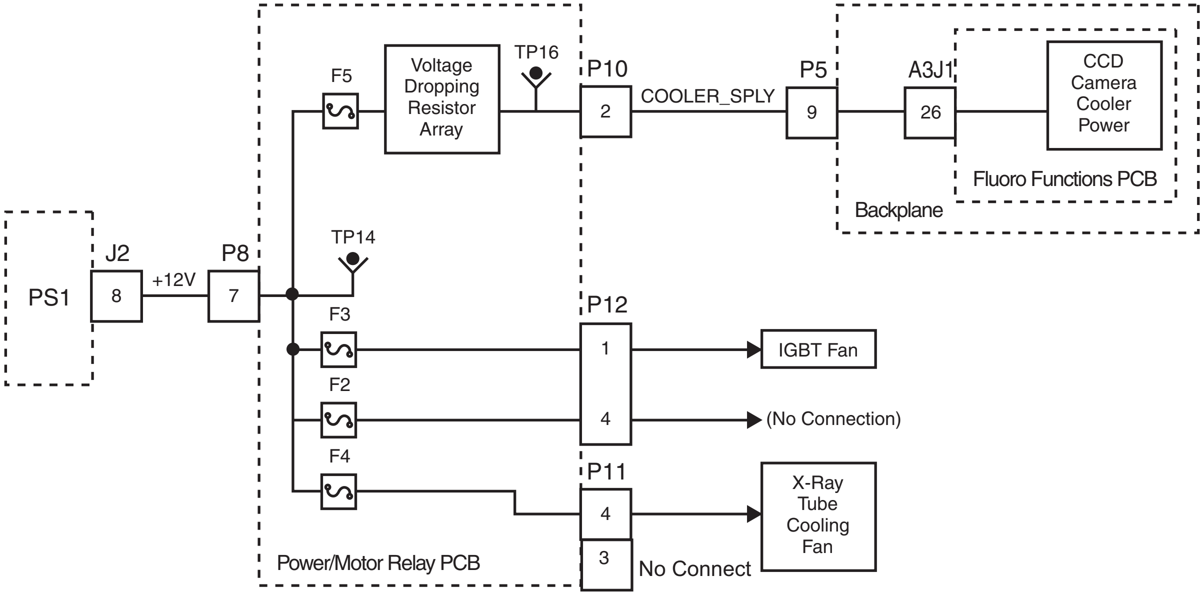
PS1 +5VDC Output (sheet 2 of 3)


J1
17
18
19
TP3
VCC
FL2
J2
1
2
3
Control Panel
Processor PCB
P4
VCC
17
18
19
P5
1
2
3
TP2
VCC
FL1
P1
VCC
17
18
19
20
21
VCC
P1
17
18
19
20
21
Left Control Panel
(Key/Display)
From +5 Output
Sheet 2
P3
+5V CPP
10
+5V CPP
11
Alarm +5V
15
Alarm +5V
Alarm +5V
Alarm
P6
1
Alarm +5V
J4
1
TP3
P7
1
Alarm +5V
J4
1
P2
VCC
17
18
19
20
21
VCC
VCC
P1
17
18
19
20
21
Right Control Panel
(Key/Display)
Control Panel Processor I/O PCB

PS1 +5VDC Output (sheet 3 of 3)

+12VDC Output

For an illustration of the PS1 +12VDC output, refer to the following diagram:

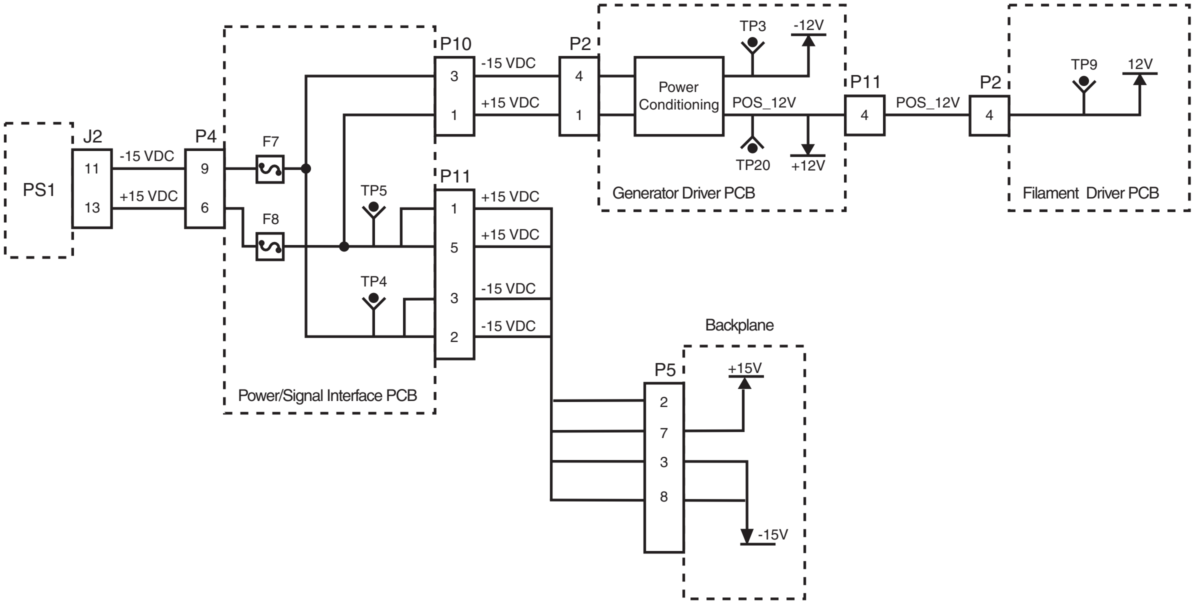

PS1
J2
8
+12V
P8
7
TP14
F5
Voltage Dropping Resistor Array
TP16
P10
2
COOLER_SPLY
P5
9
A3J1
26
CCD Camera Cooler Power
Fluoro Functions PCB
Backplane
F3
F2
F4
P12
1
4
IGBT Fan
(No Connection)
P11
4
3
No Connect
X-Ray Tube Cooling Fan
Power/Motor Relay PCB

PS1 +12VDC Output

PS1 provides one line of +12VDC to Connector P8 of the Power/Motor Relay PCB, where it divides into separate circuits protected by Fuse F2, F3, F4, and F5. F2 connects to P12-4, and is not used. F3 connects to P12-1, which in turn goes to the IGBT PCB fan. F4 leaves the board via Connector P11, providing power to the X-ray tube cooling fan. F5 is processed by a voltage dropping resistor array, and exits the board via Connector P10 as COOLER_SPLY, going to the CCD Camera cooling control circuitry.

±15VDC Output

For an illustration of the PS1 ±15VDC output, refer to the following diagram:


PS1
J2
11
13
-15 VDC
+15 VDC
P4
9
6
F7
F8
TP5
TP4
Power/Signal Interface PCB
P10
3
1
-15 VDC
+15 VDC
P11
1
5
3
2
+15 VDC
+15 VDC
-15 VDC
-15 VDC
P2
4
1
Power Conditioning
TP3
-12V
POS_12V
TP20
+12V
Generator Driver PCB
P11
4
POS_12V
P2
4
TP9
12V
Filament Driver PCB
Backplane
P5
2
7
3
8
+15V
-15V

PS1 ±15VDC Output

PS1 provides one line each of –15VDC and +15VDC to the Power/Signal Interface PCB, where each line is divided such that there are 3 pairs exiting the board. One pair consists of a plus and a minus voltage. Another pair consists of two positive lines. A third pair consists of two negative lines. Fuse F7 protects the three negative lines, and Fuse F8 takes care of the three positive lines.

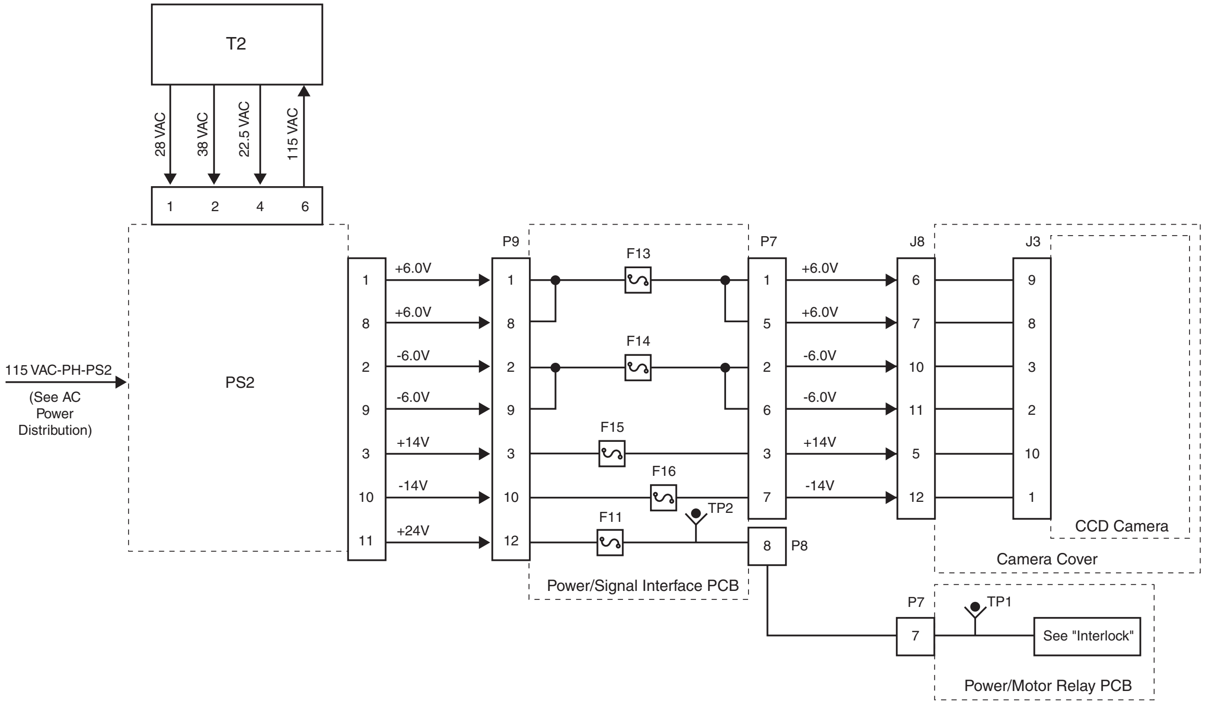
The ±15VDC pair exits the board from P10, and connects to the Generator Driver PCB, where they are processed by power conditioning circuitry that produces -12 and +12 volts for operation of the board, and also the POS_12V, which exits via P11 going to the Filament Driver PCB to furnish that board’s 12-volt operating power.

The +15VDC and –15 VDC lines exit the board at P11, going to the Backplane. The +15VDC provides operating power. Both are provided through edge connector hookup to the three PCBs that reside on the Backplane.

PS2 Output

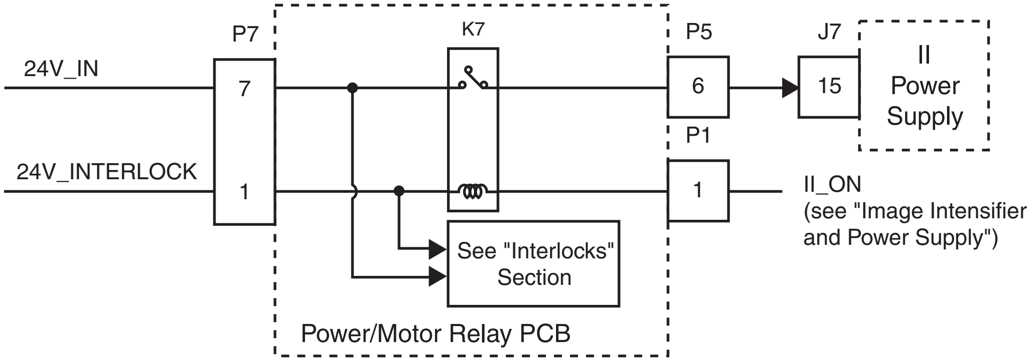
Power Supply PS2 provides operating power for the CCD camera, Image Intensifier power supply, and the Interlocks. However, before discussing the PS2 outputs, you should understand more about the 115VAC *input* to PS2 as illustrated in the AC Power Distribution diagram below. The 115VAC connects directly to PS2, as shown. However, that input goes internally direct to the T2 transformer, which is a separate FRU in the Stator system (see *Stator Control*, later in this manual). T2 then provides the true AC inputs to PS2. In the next diagram, you can see those AC inputs, as well as the DC outputs.

Notice in the diagram below that all the PS2 outputs connect to the Power/Signal Interface PCB, in order to give you test points and fuse protection for each individual main circuit. From there, all outputs except the +24 VDC supply provide the various DC voltages needed for operation of the CCD Camera. The +24VDC supplies operating power for the Image Intensifier power supply and the Interlocks system (see the *Interlocks* chapter, later in this manual.


T2
28 VAC
38 VAC
22.5 VAC
115 VAC
1 2 4 6
115 VAC-PH-PS2
(See AC Power Distribution)
PS2
+6.0V
+6.0V
-6.0V
-6.0V
+14V
-14V
+24V
P9
F13
F14
F15
F16
F11
TP2
Power/Signal Interface PCB
P7
P8
J8
J3
CCD Camera
Camera Cover
TP1
See "Interlock"
Power/Motor Relay PCB

Power Supply PS2 Outputs

The operating power for the Interlock system and the Image Intensifier power supply is further divided as shown in the next diagram.



24V_IN
24V_INTERLOCK
P7
7
1
K7
See "Interlocks" Section
Power/Motor Relay PCB
P5
6
P1
1
J7
15
II Power Supply
II_ON
(see "Image Intensifier and Power Supply")

DC Operating Power for CCD Camera and Image Intensifier

In the Power/Signal Interface PCB, the +24VDC is divided into two separate circuits. The 24V_INTERLOCK does two things---connects directly to the Interlock system, and also to the K7 relay coil, then to the Image Intensifier as II_ON. The II_ON becomes a status signal monitored by the X-ray Controller PCB.

The 24V_IN goes into the Interlock system, and also to the K7 relay contact. Thus, with the PS2 +24VDC circuit energized, K7 controls power to the Image Intensifier power supply.

PS3 Output

Power Supply PS3 receives operating power as shown in the *AC Power Distribution* chapter of this manual. The PS3 output is dedicated strictly to the vertical column. For details see the *Vertical Column* chapter of this manual.

Functional Tests

To functionally test the DC Power Distribution function, perform the following applicable tests

1. PS 1 Testing
   - A. A short or overload on any PS1 output causes that output to drop. Look for obvious problems like shorted or loose connections on P1 and P2.
   - B. There are no designated test points for PS1. However, check inputs by probing P1 and outputs by probing P2.
   - C. If PS1 outputs continue to be incorrect, perform calibration (see *Calibration* chapter in this manual). If the calibration does not correct the outputs problem, replace PS1
2. PS2 Testing
   - A. Check the following test points and indicator lights on PS2.

Test Point	Indicator Light	Voltage
TP2	DS3	-14VDC
TP3	DS2	+24VDC
TP4	DS4	+14VDC
TP5	DS1	+6VDC
TP6	DS5	-6VDC

   - B. A short or overload on any PS1 output causes that output to drop. Look for obvious problems like shorted or loose connections on input and output connectors.
3. PS3 Testing

   There are no accessible circuit breakers or fuses on the power supply itself. However check output connector P6 on Power/Signal Interface PCB and the PS3 input connector for loose connections and probe for correct voltage of 115VAC.

Fault Isolation

Failure	Possible Cause	Remedy
Hand Switch indicator lights off; VFDs OK; bootup OK	Blown fuse F7 on Power/Motor Relay PCB	Replace fuse.
	Loose connectors	Check Connectors P8 and P9 on Power/Motor Relay PCB. Also check Hand Switch connector J3/P3.
VFDs inoperative. Handswitch Indicator lights OK; bootup otherwise OK	Blown fuse F12 on Power/Signal Interface PCB.	Replace fuse.
	Loose connectors	Check Connectors P6 on Power/Signal Interface PCB, and P3 on Control Panel Processor I/O PCB.
VFDs, Handswitch indicator lights OK, no bootup	Blown fuse F9 on Power/Signal Interface PCB	Replace fuse.
	Loose connectors	Check Connector P11 on Power/Signal Interface PCB.
		Check Connectors P5 on Backplane, and P2 on Generator Driver PCB.
Interlock system down, preventing X-rays and resetting the system	Blown fuse F11 on Power/Signal Interface PCB.	Replace fuse
		Check test points and indicator lights.
	+24VDC section of PS2 failed	Replace PS2
No video, no pilot tone (“LIVE” message does not appear in lower right-hand corner of Workstation left-hand monitor).	Blown fuses F13 or F14	Replace fuses

Failure	**Possible Cause**	**Remedy**
		Check connector P7 on the Power/Signal Interface PCB
	+ or –6VDC section of PS2 failed	Check test points and indicator lights.
No video, but pilot tone OK	Blown fuses F15 or F16	Replace fuses
		Check connector P7 on the Power/Signal Interface PCB
	+ or –14VDC sections of PS@ failed	Replace PS2
Neither Vertical Lift Column lift button works	AC input problem	Refer to *AC Power Distribution* chapter in this manual
One lift button works, but the other one does not	Defective switch	Check switch continuity (each switch contains two momentary closure SPST switches).

Adjustment

Adjustments for PS1 are provided in the *Calibration* section of this manual.

Miscellaneous

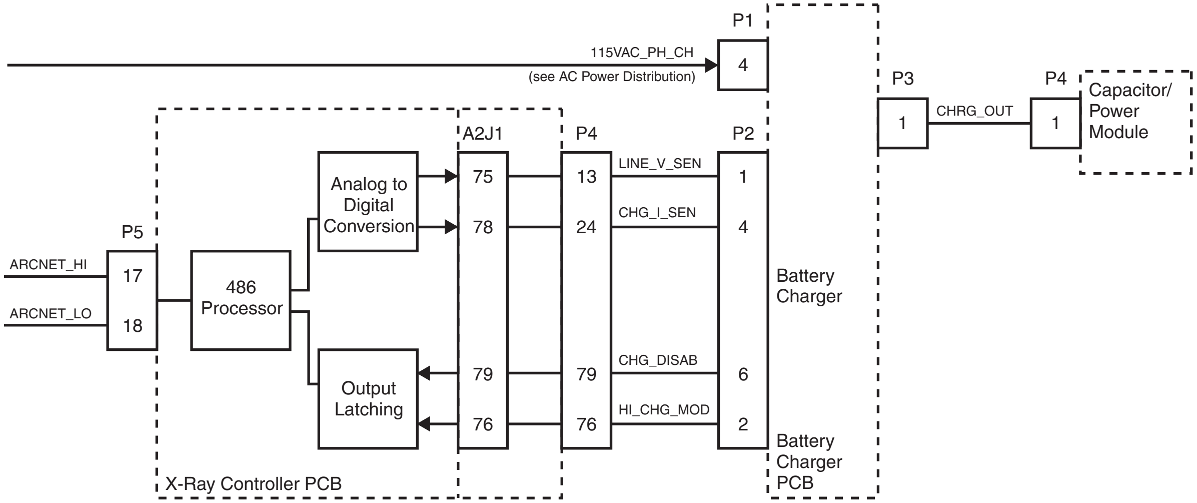
DC Power Distribution

Battery Charging

Circuit/Mechanical Descriptions....2
Functional Tests....3
Fault Isolation....4
Adjustment....5
Miscellaneous....5

Circuit/Mechanical Descriptions

The battery charging circuitry is illustrated in the following diagram:


P1
115VAC_PH_CH
(see AC Power Distribution)
4
P3
1
CHRG_OUT
P4
1
Capacitor/
Power
Module
A2J1
P4
P2
LINE_V_SEN
CHG_I_SEN
Analog to
Digital
Conversion
75
78
13
24
1
4
P5
ARCNET_HI
ARCNET_LO
17
18
486
Processor
Battery
Charger
Output
Latching
79
76
79
76
CHG_DISAB
HI_CHG_MOD
6
2
X-Ray Controller PCB
Battery
Charger
PCB

Battery Charging Circuitry

When you turn on the Workstation, 115 VAC becomes available at the Battery Charger PCB, as previously explained in the *AC Power Distribution* section of this manual. At the same time, DC power energizes the X-Ray Controller PCB, as described in the *DC Power Distribution* section. With the X-Ray Controller PCB energized, signals exchanged between the two boards regulate charger output according to battery charge and power demands of taking X-Ray shots. There are several LED indicators on the Battery Charger PCB that indicate operation. For full information about them, you should refer to the *Diagnostics* chapter of this manual.

Charger output goes to the battery via the Capacitor/Power Module. The following information about charger operation is not visible in the diagram above, however you should be familiar with how the charger itself operates.

- The charger has three modes of operation: high charge, normal charge, and trickle charge.
- During high charge mode, input voltage of 115VAC is rectified and boosted with power factor correction and battery voltage is maintained at 235VDC.
- During normal charge mode, battery voltage is maintained at 225VDC.
- If battery load voltage drops below 163VDC, internal chager circuitry shuts off output and the charger goes into trickle charge mode until battery voltage rebuilds. This is to protect the charger from high currents caused by low battery voltage such as during heavy use or if the system is left unplugged for too long.
- Notice that the charger indicator light (see *AC Power Distribution* chapter , this manual) is supposed to be lit at all times, as long as the C-Arm is connected to the Workstation and the Workstation is plugged in, regardless of whether the C-Arm is booted up.

Functional Tests

To functionally test the Battery Charging function, perform the following applicable tests (see *C-Arm Subsystem* chapter of this manual).

- Boot Test
- Fluoro Mode Performance Check
- Film Mode Performance Check

Fault Isolation

Failure	**Possible Cause**	**Remedy**
Battery charger inoperative	The Workstation disconnected from AC line or the AC line goes down.	Check AC connections to Workstation
	The Workstation Interconnect Cable disconnected from the C-Arm.	Check Interconnect Cable
	A fuse blows or the Battery Charger fails.	Replace fuses (see AC and DC power chapters of this manual.
	Instantaneous peak battery charging current exceeds 15.5 amps, causing an Overcurrent shutdown of the Battery Charger.	Power down or CHG_DISAB will reset the fault latch and allow normal operation. Check for shorts at the battery charger output. -MW
	Output voltage exceeds 250 Volts, causing an Overvoltage shutdown of the Battery Charger.	Power down or CHG_DISAB will reset the fault latch. Check that the CB1 circuit breaker is turned on.
	The X-Ray Controller asserts the CHG_DISAB signal to turn the Battery Charger off	This is a normal function during the precharging period and whenever the Codonics printer is operating.

Adjustment

Battery charger output voltage under normal charging operation should be adjusted to produce 225.0V at TP1 relative to TP3 using R71. TP3 is not installed. Use meter probe to connect to the exposed hole at this location. The trimpot R71 turns counterclockwise to increase, or clockwise to reduce the output voltage. Check that high charge mode is not engaged. If the battery charger output voltage is too high in normal charge mode, this can cause the error message PRECHARGE VOLTAGE ERROR, and prevent completion of precharging.

Miscellaneous

None

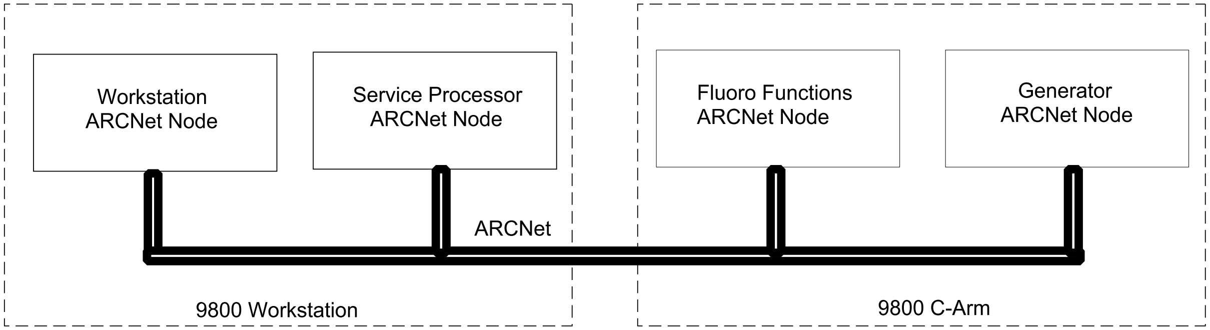
System Communications

ARCNET Communications **2**
Fluoro Functions PCB ARCNet Node 2
Generator Node 3
Frame Sync Circuitry 3
Camera - Control Panel Communication (RS422) 3
Functional Tests **4**
Fault Isolation **5**
ARCNet Waveforms 5
RS422 Serial Communication Failure 6
Adjustment **6**
Miscellaneous **6**

ARCNET Communications

Communications within the system between the four system microprocessors is by means of ARCNet, generated by a Universal Local Area Network Controller. The term “node” refers to each microprocessor and its associated support hardware.

The ARCNet chip interfaces to other nodes by means of RS485 transceivers. The RS485 standard allows receivers and transmitters to be connected on a single pair of wire for transmitted and received data. Incoming data causes the node ARCNet chip to interrupt the processor.


Workstation ARCNet Node
Service Processor ARCNet Node
Fluoro Functions ARCNet Node
Generator ARCNet Node
ARCNet
9800 Workstation
9800 C-Arm

ARCNet Block Diagram

Fluoro Functions PCB ARCNet Node

The Fluoro Functions PCB Node controls most mechanical elements associated with the C-Arm, i.e., collimator iris, leaves, camera and leaf rotation, etc. The node also interfaces with the X-Ray Control Panel and displays all messages and techniques on the control panel.

Generator Node

The Generator Node on the X-Ray Controller PCB controls the electrical components that determine x-ray technique, pulse rates, etc. Technique and shot data gathered by the X-Ray Controller PCB during and after the exposure are sent to the Workstation Node for display on the monitors as well as being sent to the Fluoro Functions PCB Node for display on the X-Ray Control Panel.

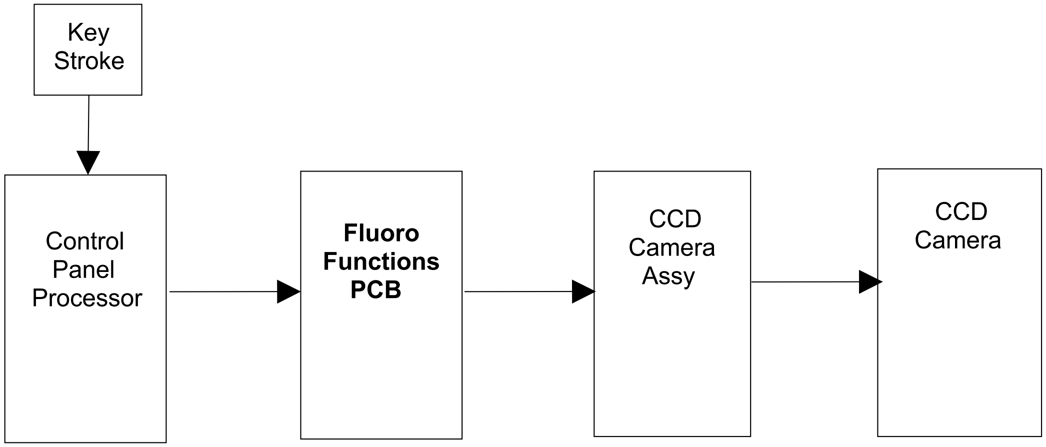
Frame Sync Circuitry

The frame sync circuitry is composed of the circuitry associated with RS485 receiver U45 and PLD U37 on the X-Ray Controller PCB. The incoming frame sync signal, INT_SYNC*, is a 190 microsecond active low signal that is buffered by U45. This signal is digitally filtered by U37 to prevent noise spikes from falsely interrupting the microcontroller.

Camera - Control Panel Communication (RS422)

When a key is pressed on the C-Arm keyboard, a hex value is sent from the Control Panel Processor PCB to the Fluoro Functions PCB in the C-Arm by RS-422 serial communications.

The RS422 signal is routed from the Control Panel Processor PCB, through the Control Panel Processor I/O PCB to the Power/Signal Interface PCB, through the back-plane, and is received by quad receiver U57 on the Fluoro Functions PCB. The output of U57 is fed to Micro-controller U36.


Key Stroke
Control Panel Processor
Fluoro Functions PCB
CCD Camera Assy
CCD Camera

CCD Camera Serial Communications

The Fluoro Functions PCB responds to this input by sending data back from RS422 driver U58 through the interconnection cable to RS422 receiver U4 on the Control Panel Processor PCB and Microcontroller U11.

Functional Tests

None

Fault Isolation

ARCNet Waveforms

The ARCNet is the primary control path in the Series 9800 Mobile Digital Imaging system.

There are two nodes in the C-Arm:

1. The Fluoro Functions PCB.

2. The X-Ray Controller PCB.

The System Interface PCB, which occupies an ISA slot on the Host CPU motherboard in the Workstation, has two independent ARCNet nodes:

3. The 9800 System ARCNet host, or **Workstation** node. This node has two junctions. The first junction communicates with any external ARCNet devices that may be connected to the Workstation rear panel. The second junction provides ARCNet communication to the C-Arm through the Interconnect cable.

4. The Remote Diagnostics Gateway, or **Service** node. This node provides a data pathway between the system ARCNet and the serial interface to the Remote Utility Suite.

You can use a digital oscilloscope to observe ARCNet signals anywhere on the ARCNet bus. It is most convenient on the C-Arm, where you can place either the Fluoro Functions PCB or X-Ray Controller PCB on an extender card. A procedure for checking ARCNet communications is contained in the *Diagnostics Section* of this manual.

An illustration showing all four ARCNet nodes active is also contained in the *Diagnostic section* of this manual. Investigate all inactive nodes. Subsequent illustrations show individual node details.

RS422 Serial Communication Failure

Check PCB seating and cabling. Check the test points for the correct voltage levels.

Adjustment

None

Miscellaneous

None

Interlocks

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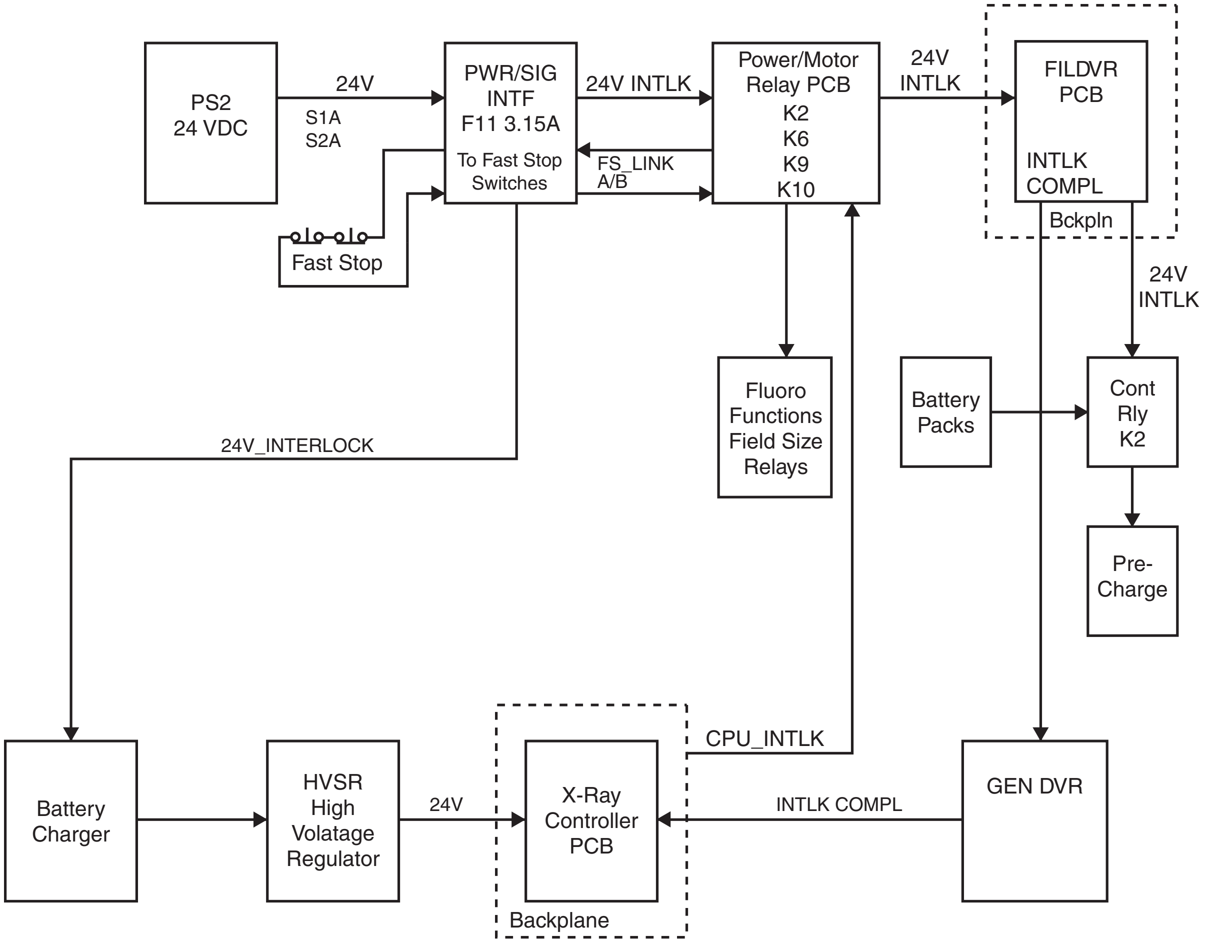
Functional Tests 4
Fault Isolation 5
Adjustment 5
Miscellaneous 6

Circuit/Mechanical Descriptions

The Interlock system for the 9800 Imaging System consists of circuitry that connects each of the PCBs that are used in generating X-rays. If any of these circuits are broken, the system is prevented from emitting X-rays until the fault is repaired. The interlock loop can be broken by pressing the Fast-Stop buttons, by a wire/connection break, or by software via the X-Ray Controller CPU_Interlock signal.

The system utilizes relays that are not energized until the electrical path throughout the system is complete. Several of these relays control power to the system motors and power to the pre-charge capacitor bank that provides high voltage for X-ray generation.


PS2
24 VDC
24V
S1A
S2A
PWR/SIG
INTF
F11 3.15A
To Fast Stop
Switches
Fast Stop
24V INTLK
FS_LINK
A/B
Power/Motor
Relay PCB
K2
K6
K9
K10
24V
INTLK
FILDVR
PCB
INTLK
COMPL
Bckpln
24V
INTLK
Fluoro
Functions
Field Size
Relays
Battery
Packs
Cont
Rly
K2
Pre-
Charge
24V_INTERLOCK
Battery
Charger
HVSR
High
Volatage
Regulator
24V
X-Ray
Controller
PCB
Backplane
CPU_INTLK
INTLK COMPL
GEN DVR

Functional Tests

Perform the following tests to verify that the system is operating satisfactorily.

(Refer to the *9800 C-Arm Sub-system* chapter of this manual for Functional Tests.)

1. System Boot
2. Make a fluoroscopic exposure
3. Press one of the Fast Stop buttons on the C-arm Control Panel. The message “FAST STOP ACTIVATED. POWER DOWN. WAIT 5 SECONDS” should be displayed. X-ray generation should be disabled.

Fault Isolation

Failure	Possible Cause	Remedy
Interlocks broken	Interlock path is open	Check interlock path for open circuit. Check cables and connectors
System does not boot – stops at 18th arrow on Control Panel	System Interlocks open	Check interlock path for open circuit. Check cables and connectors Check Intlk_Complt* line to X-Ray Controller PCB for low. If high, interlock path is open.
System does not boot – stops at 14th arrow	Interlocks open	Check TP4 on Power Motor Relay PCB. This TP goes to +24 VDC at the 14th arrow if interlocks are intact during bootup. Check interlock path, cables and connectors.

Adjustment

Not applicable.

Miscellaneous

None

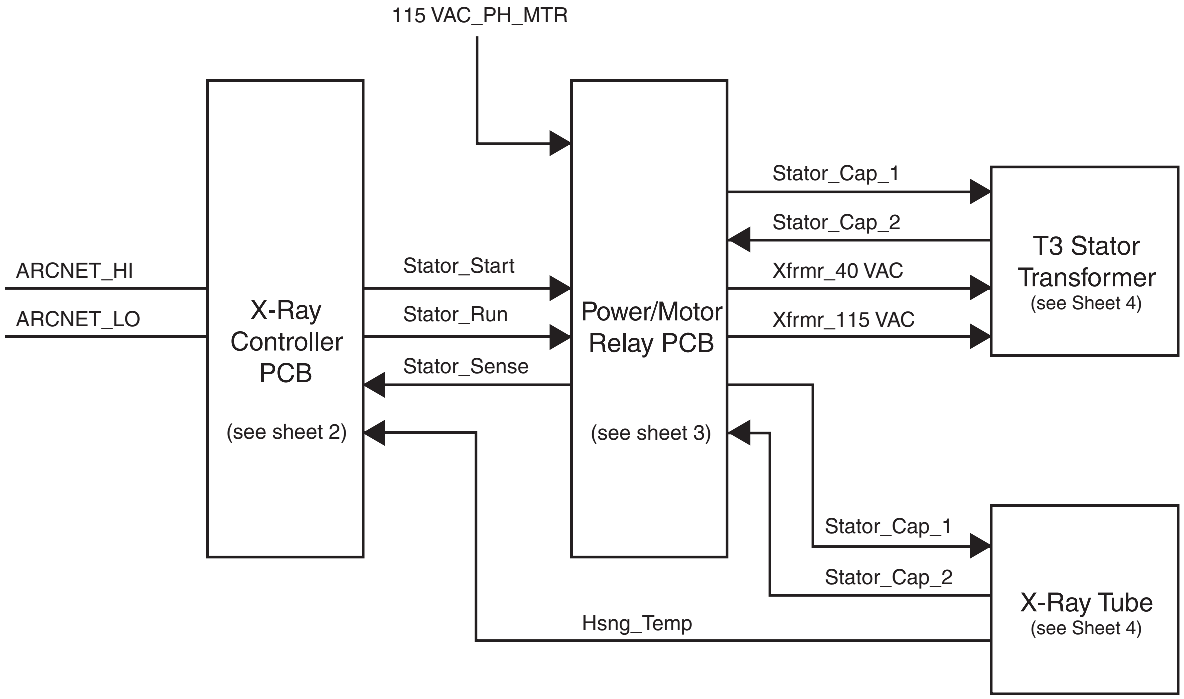
Stator Power and Control

Circuit/Mechanical Descriptions **2**
Stator Power and Control 2
Filament Selection 4
Functional Tests **4**
Fault Isolation **5**
Adjustment **6**
Miscellaneous **6**

Circuit/Mechanical Descriptions

Stator Power and Control

An overview of the Stator Power and Control function is shown in the following:


115 VAC_PH_MTR
ARCNET_HI
ARCNET_LO
X-Ray Controller PCB
(see sheet 2)
Stator_Start
Stator_Run
Stator_Sense
Power/Motor Relay PCB
(see sheet 3)
Stator_Cap_1
Stator_Cap_2
Xfrmr_40 VAC
Xfrmr_115 VAC
T3 Stator Transformer
(see Sheet 4)
Stator_Cap_1
Stator_Cap_2
Hsng_Temp
X-Ray Tube
(see Sheet 4)

Stator Power and Control

The major components of this functional group consist of X-Ray Controller PCB, Power/Motor Relay PCB, T3 Stator Transformer, and X-Ray Tube.

1. Operation of this group begins when you place the ON/OFF switch on the Workstation in the ON position, starting the boot sequence.
2. Operating power becomes available at the Power/Motor Relay PCB (115VAC), and at the X-Ray Controller PCB (DC).
3. At the beginning of the boot sequence, the ARCNET data from the Workstation initializes the CPU on the X-Ray Controller PCB. The CPU generates a signal that starts the Interlock sequence (see *Interlocks* in this manual).
4. When the Interlock sequence is complete, stator rotation begins, in the following sequence:
    a. The X-Ray Controller PCB receives temperature status of the X-Ray tube housing and stator input voltage sense.
    b. The X-Ray Controller first activates the STATOR_START signal, which switches a relay on the Power Motor Relay PCB to select 115VAC power for the stator. It then sends a signal STATOR_RUN to the Power/Motor Relay PCB that switches 115VAC power to the T3 Stator Transformer and to the Stator coil of the X-Ray Tube. The tube anode begins to rotate. The return line passes through a thermal switch on the X-Ray Tube housing, that will open above a maximum safe temperature and stop the anode from rotating.
    c. After two seconds, when the anode reaches running speed, the X-Ray Controller causes the 115VAC to the stator and capacitor to turn off by turning off the STATOR_RUN signal on the Power/Motor Relay PCB. The signal STATOR_START is turned off 100ms later to switch 40VAC power from the T3 Stator Transformer to supply the Stator coil of the X-Ray Tube. After 100ms, the STATOR_RUN signal is turned on again, and the stator continues to run, powered by 40VAC instead of 115VAC. A STATOR_SENSE signal is monitored by the X-Ray Controller to confirm that the anode is rotating (when it is not, the current drawn by the stator coil changes, so that a failure can be detected.) If the thermal switch operates, the circuit will then shut down the system.
    d. To prevent the thermal switch from operating, which should only occur as a safety measure if the tube housing exceeds rated temperature and results in a potential oil leakage hazard, the housing temperature is monitored continuously by the X-Ray Controller PCB. If it exceeds a certain percentage of the housing heat capacity, a warning message will be displayed, alternating with the technique.
    e. The X-Ray Controller also integrates the heat input due to every X-ray shot, and calculates the tube anode temperature continuously. If the anode temperature exceeds a certain percentage of its capacity, a warning message will be displayed, alternating with the technique. Beyond a higher warning level, boosted X-ray production will be limited to avoid overheating the tube anode.

5. After about 10 minutes of idle time, the system enters “sleep” mode, and the stator drive is turned off. When reactivated, Steps a and b above are repeated before X-Rays can be made. You should be able to hear the anode whirring, and the successions of relay clicks, indicating that the system came out of sleep mode.

Filament Selection

(This information is part of the *mA Generation* chapter)

Functional Tests

To functionally test the Stator Power and Control function, perform the following applicable tests (see *C-Arm Subsystem* chapter of this manual).

- Boot Test
- Fluoro Mode Performance Check
- Film Mode Performance Check

Fault Isolation

Failure	Possible Cause	Remedy
Stator does not start during boot-up. STATOR NOT ON error message	Stator Start signal fails to activate relay	Check relay on Power Motor Relay PCB (K2). Check connections to this relay. LED across relay should light when activated. Check voltage of 24V_INTERLOCK.
	Stator Run relay fails to activate	Check relay K1 of Power Motor Relay PCB. LED across this should be on while relay is activated. Check connections
Stator stops running	System in sleep mode	Operating any C-Arm function should restart the stator. Check that the relays click and he stator restarts. If not, reboot system.
	Thermal cutout has operated	Usually with ANODE HOT and/or HOUSING HOT message displayed. Allow to cool 15 minutes and try again.
Stator runs at 115V, tube overheats.	Stator Start relay stuck on	Check voltage applied to stator to confirm. This will normally heat the system enough to give housing warm/hot messages. Check if the relay operates after being shocked. Replace Power/Motor Relay PCB.
Stator runs normally but error messages seen	STATOR_DETECT or STATOR_SEN problem	Check that STATOR_DETECT signal on X-Ray Controller goes low when the stator is running. Wait 10-15 minutes until system enters sleep mode, verify that STATOR_DETECT goes high. Readings at analog multiplexer input (U48 pin 20) should be 5.7V in stator start mode, 3.4V when running normally, and zero when stator is turned off in sleep mode..

Adjustment

None

Miscellaneous

Stator Transformer T3 also supplies the precharge circuitry on the Filament Driver PCB. Precharge is initiated after the stator start-run sequence has been completed. See the *Precharge* chapter of this manual.

Pre-Charging

Circuit/Mechanical Descriptions....2
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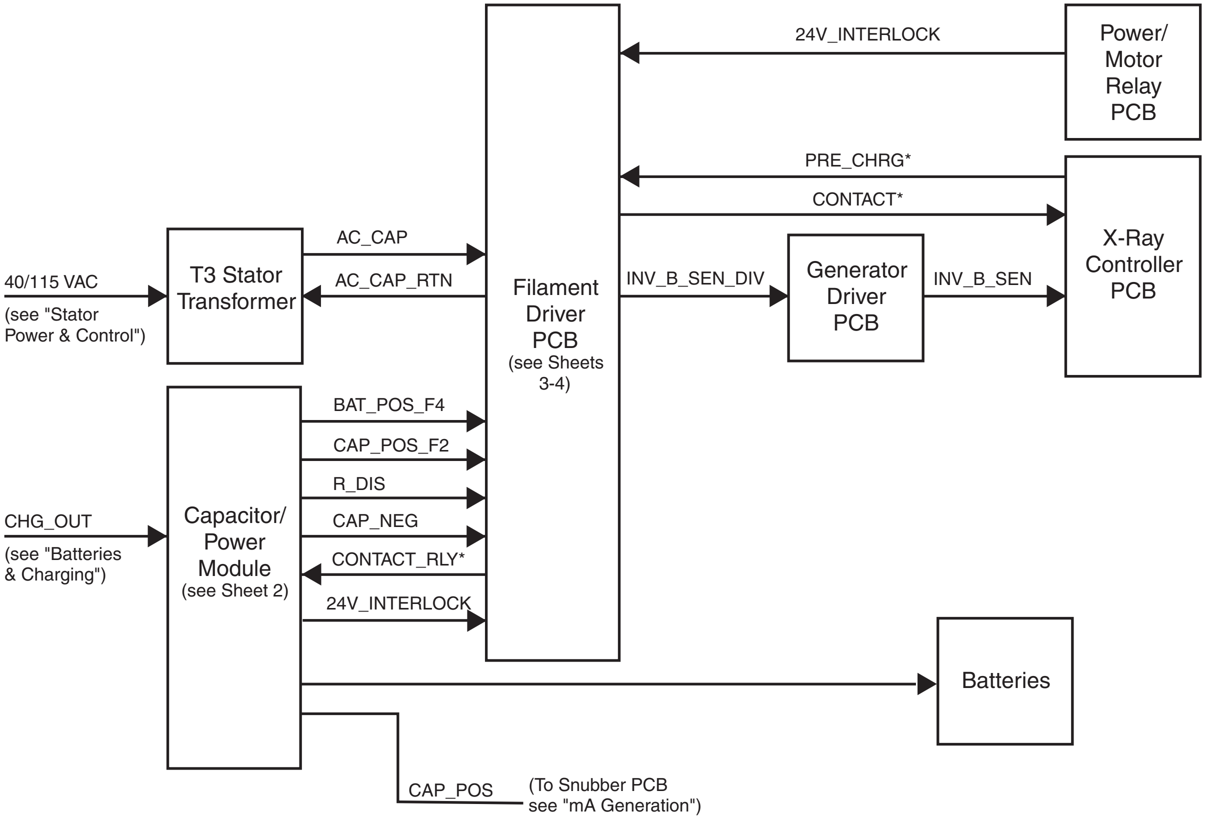
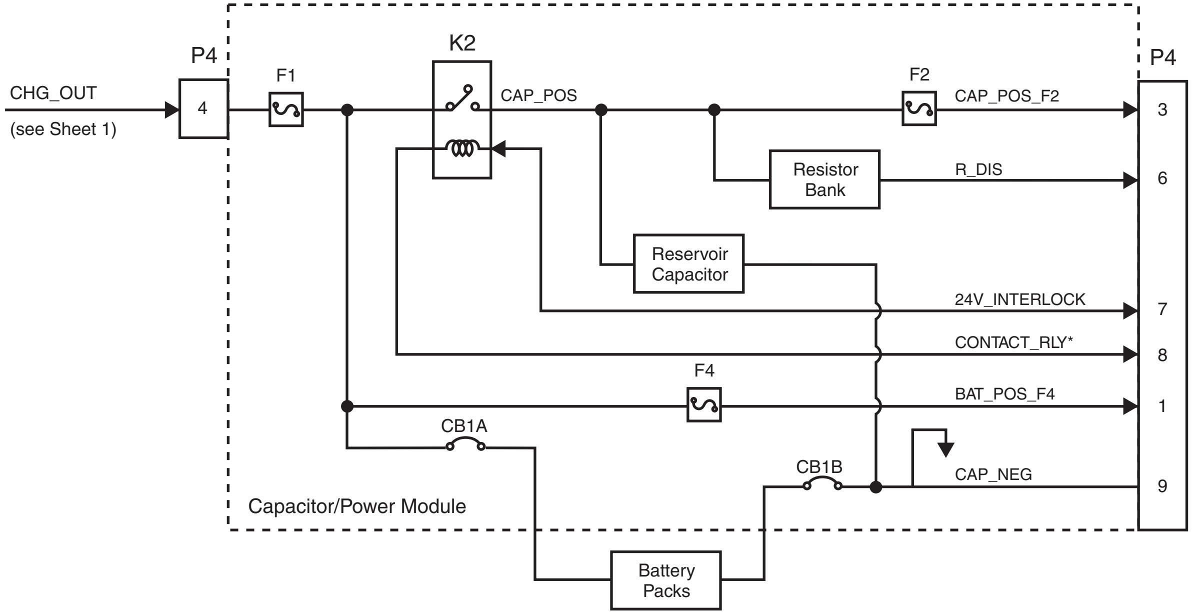
Fault Isolation....7
Adjustment....7
Miscellaneous....7

Circuit/Mechanical Descriptions

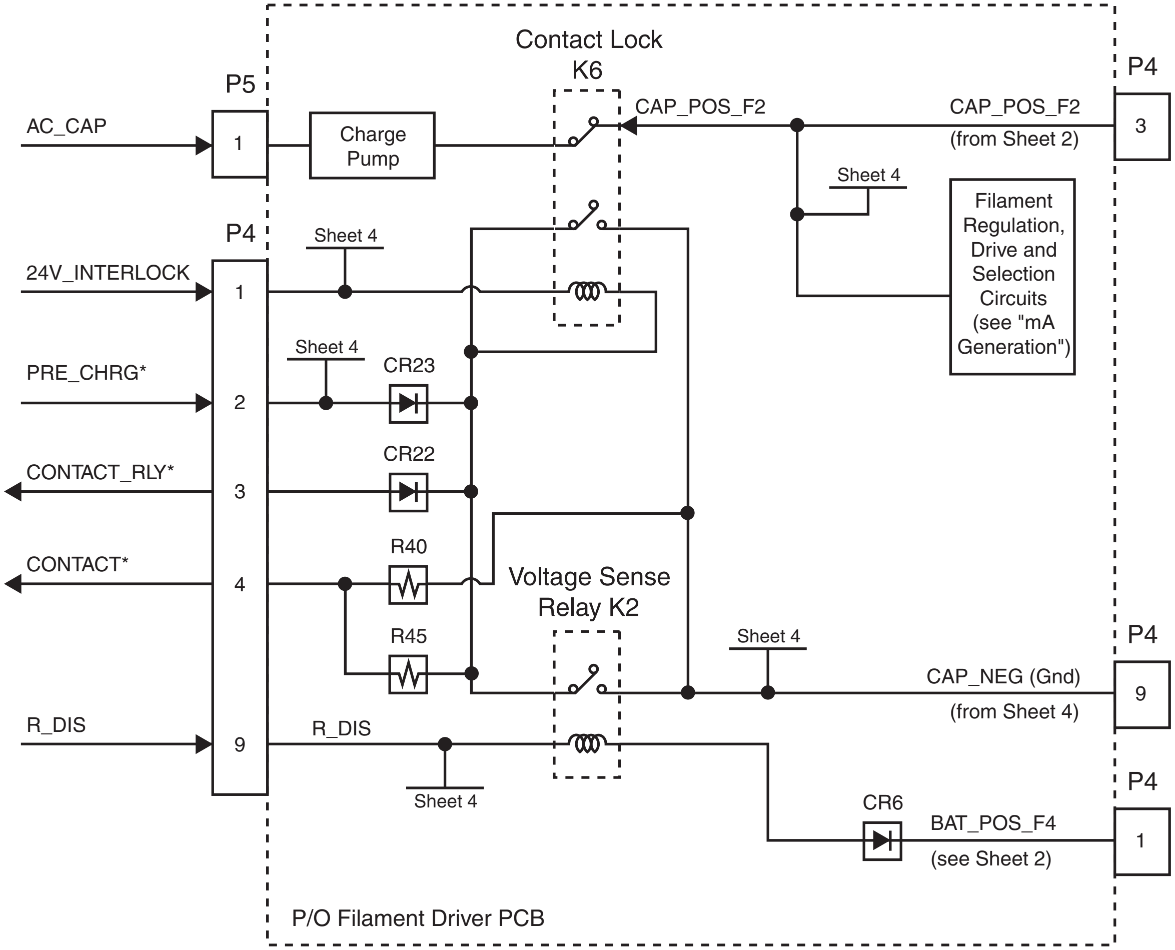
An explanation of the Pre-charging function is shown in the following diagrams, sheets 1 through 4:


Power/ Motor Relay PCB
24V_INTERLOCK
PRE_CHRG*
CONTACT*
X-Ray Controller PCB
INV_B_SEN
Generator Driver PCB
INV_B_SEN_DIV
Filament Driver PCB (see Sheets 3-4)
AC_CAP
AC_CAP_RTN
T3 Stator Transformer
40/115 VAC
(see "Stator Power & Control")
BAT_POS_F4
CAP_POS_F2
R_DIS
CAP_NEG
CONTACT_RLY*
24V_INTERLOCK
Capacitor/ Power Module (see Sheet 2)
CHG_OUT
(see "Batteries & Charging")
Batteries
CAP_POS
(To Snubber PCB see "mA Generation")

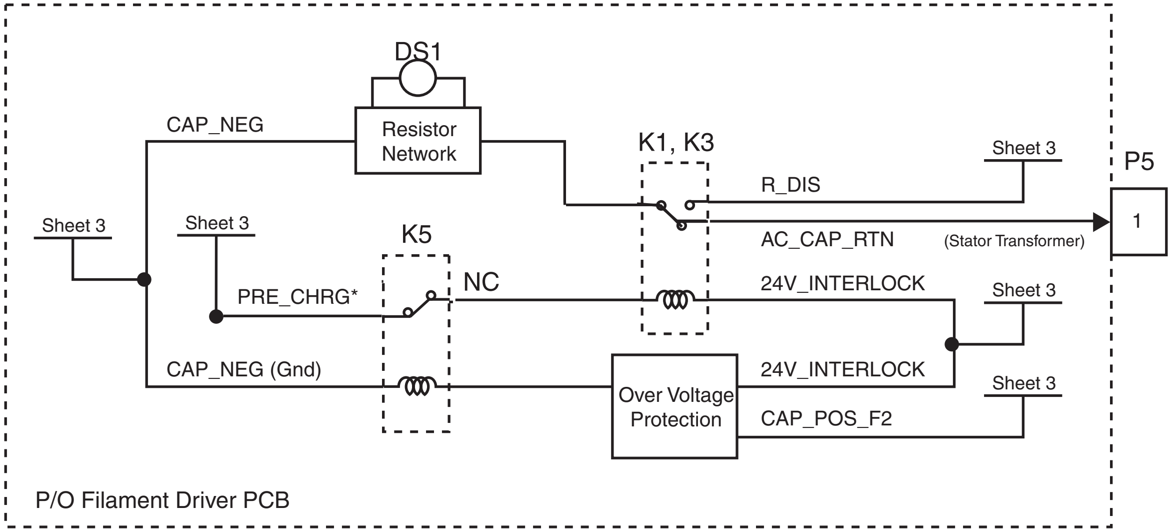
Pre-charging (sheet 1)


CHG_OUT
(see Sheet 1)
P4
4
F1
K2
CAP_POS
F2
CAP_POS_F2
P4
3
Resistor Bank
R_DIS
6
Reservoir Capacitor
24V_INTERLOCK
7
CONTACT_RLY*
8
F4
BAT_POS_F4
1
CB1A
CB1B
CAP_NEG
9
Capacitor/Power Module
Battery Packs

Pre-charging (Sheet 2)


Contact Lock
K6
P5
AC_CAP
1
Charge Pump
CAP_POS_F2
CAP_POS_F2
(from Sheet 2)
P4
3
Sheet 4
Filament Regulation, Drive and Selection Circuits (see "mA Generation")
P4
Sheet 4
24V_INTERLOCK
1
Sheet 4
PRE_CHRG*
2
CR23
CONTACT_RLY*
3
CR22
CONTACT*
4
R40
Voltage Sense Relay K2
R45
Sheet 4
P4
CAP_NEG (Gnd)
(from Sheet 4)
9
R_DIS
9
R_DIS
Sheet 4
P4
CR6
BAT_POS_F4
(see Sheet 2)
1
P/O Filament Driver PCB

Pre-charging (sheet 3)


DS1
Resistor Network
CAP_NEG
K1, K3
Sheet 3
P5
R_DIS
1
AC_CAP_RTN
(Stator Transformer)
Sheet 3
Sheet 3
K5
NC
PRE_CHRG*
24V_INTERLOCK
Sheet 3
24V_INTERLOCK
CAP_NEG (Gnd)
Over Voltage Protection
Sheet 3
CAP_POS_F2
P/O Filament Driver PCB

Pre-charging (sheet 4)

The PRE-CHRG* signal from the X-Ray Controller PCB turns on relays K1/K3 on the Filament Driver PCB, opening a path of 115VAC output from the secondary of the stator transformer to the Filament Driver PCB. Charging current is generated by applying this voltage to a charge pump arrangement of rectifiers on the Filament Driver PCB. When this voltage reaches a few volts above the battery voltage, relays K2/K6 (see sheet 3) combine to turn on contactor K2 on the Capacitor/Power Module, which switches battery power directly across the capacitor bank. Completion of Precharge disables software control to prevent a subsequent software failure from turning off the pre-charge relays while the system is in normal use.

R_DIS is connected when relays K1/K3 are off. AC_CAP_RTN is connected wehn K1/K3 are turned on. PRE_CHRG* is connected unless overvoltage protection turns on relay K5.

As a safety feature, the X-ray Controller PCB also monitors the pre-charging process. In that event, the system will indicate a pre-charge failure. If the voltage at the reservoir capacitor fails to reach the battery voltage, or if it exceeds the maximum of 250V, software will disable pre-charging. If fuse F2 on the Capacitor/Power Module is blown, the software will typically disable pre-charging, but will not show the error message until after it completes booting up.

If the voltage on the pre-charging capacitors reaches about 280V, a relay on the Filament Driver PCB will operate, disconnecting the pre-charge relays, and forcing the voltage to cycle between 280V and about 180V. Eventually, software will fail to boot fully, and the operator will restart the system or call for service.

Functional Tests

To test the Pre-charge function, perform the functional tests in the *C-Arm Subsystem* chapter. Most failures will be manifested by error messages. Use the instructions supplied with the error messages in the *Diagnostics* chapter, in conjunction with the fault isolation procedures in the following secton.

Fault Isolation

Failure	Possible Cause	Remedy
System does not complete pre-charging, PRECHARGE VOLTAGE ERROR is displayed	CB1 under the C-Arm is not closed.	Verify that CB1 is turned on. If not, turn it on. If it trips, call service technician.
	F4 in Cap/Power Module is open.	Service technician will need to replace fuse.
System does not complete pre-charging, PRECHARGE TIME-OUT ERROR is displayed	F2 in Cap/Power Module is open.	Service technician will need to replace fuse.
	Connector is open.	Check connectors.
System does not complete pre-charging, but relays click every few seconds.	Software failure occurred and overvoltage protection is activated.	Try rebooting. If fault persists, service technician will need to diagnose. Do not leave system turned on, as some components will become hot.

Adjustment

None

Miscellaneous

The PRE-CHARGE VOLTAGE ERROR message may occur if the battery charger is set to higher than the normal 225.0VDC output in normal charging mode, with battery pack fully charged. This is especially applicable if AC power is at the low voltage limit (10 percent lower than normal), with 50 Hz AC power. Check the *Battery Charger* chapter of this manual for details.

Other common faults are bad connections inside the Cap/Power Module, blown fuses, or battery packs that are overcharged if left active overnight.

X-Ray On, X-Ray Disable

Circuit/Mechanical Descriptions **2**
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Miscellaneous **7**
  Signal Names and Functions 7
    X-Ray Controller PCB 00-879625 7
    Digital Logic Signal Levels 9
    Standard Interface Analog Signal Levels 12

Circuit/Mechanical Descriptions

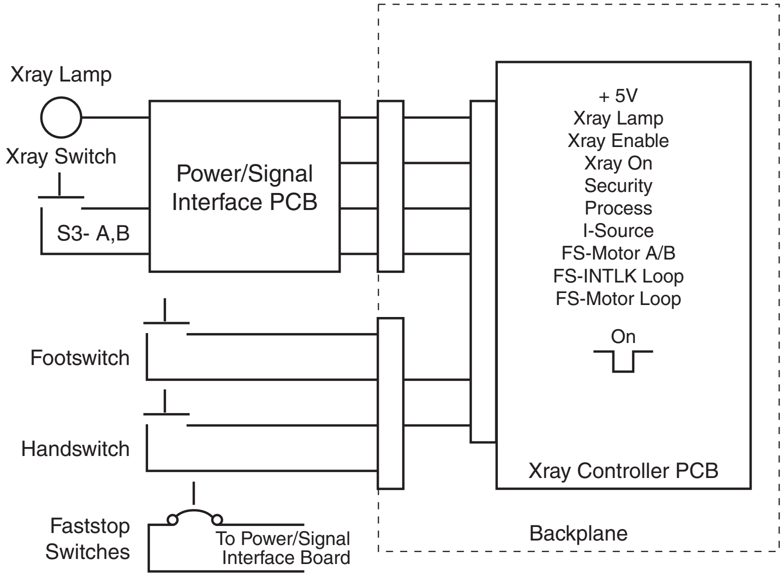
The X-ray On Switch located on top of the Cross Arm cover sends an enable signal through the Power/Signal Interface PCB to the X-ray Controller PCB to initiate an x-ray exposure. The X-ray Lamp lights when an exposure occurs.

The X-ray Controller PCB is the interface for the Generator subsystem to the ARCNET for control of X-ray generation and also enables the status display on the C-Arm Control Panels and Workstation monitors. The PCB controls kV and mA generation and regulation. The PCB also interfaces to the Handswitch and Footswitch.

The Fast Stop switches are located on the rear of the Cross-Arm Side Cover and are connected to the Power/Signal Interface PCB. One set of the dual contacts of each switch removes power from the tube stator transformer and software immediately stops x-rays. The other contact set removes +24VDC power from the vertical column motor K15 and K16 relays to prevent motorized mechanical motion.

An HLF or FLUORO Footswitch command goes through an opto-isolator to the microprocessor on the X-ray Controller PCB. This MODE switch command is also input to the X-ray Controller PCB and communicated to the Workstation via ARCNET.

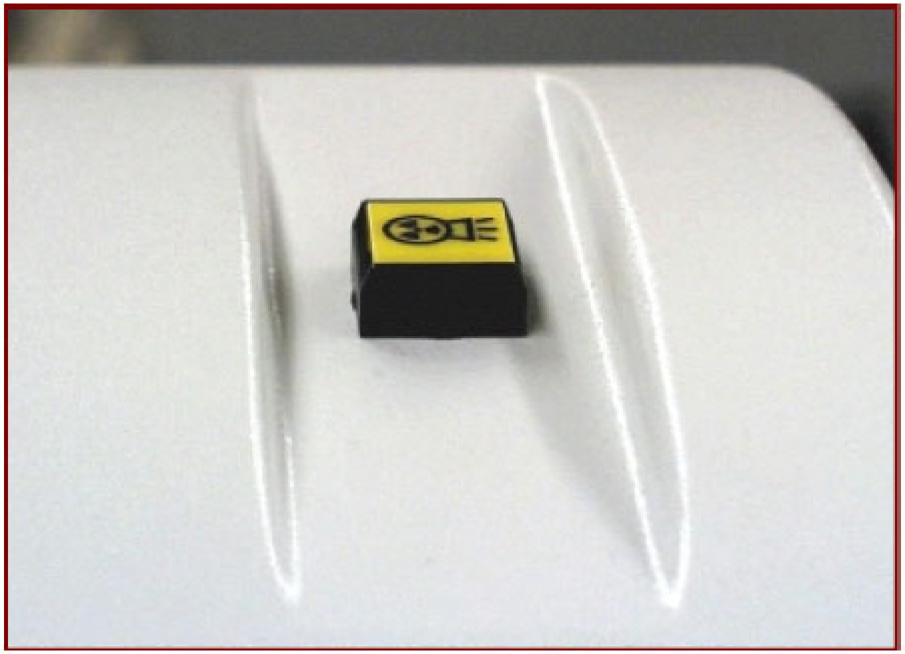
The SECURITY line from the Footswitch or Handswitch is output from the X-ray Controller PCB as the X-ray Enable signal line to the HV Supply Regulator PCB. A low on this signal line provides a shutdown capability via PWM U12 on this PCB. The shutdown occurs when all PWM driver outputs to the Generator Driver PCB are asserted low.


Xray Lamp
Xray Switch
S3- A,B
Power/Signal Interface PCB
Footswitch
Handswitch
Faststop Switches
To Power/Signal Interface Board
+ 5V
Xray Lamp
Xray Enable
Xray On
Security
Process
I-Source
FS-Motor A/B
FS-INTLK Loop
FS-Motor Loop
On
Xray Controller PCB
Backplane

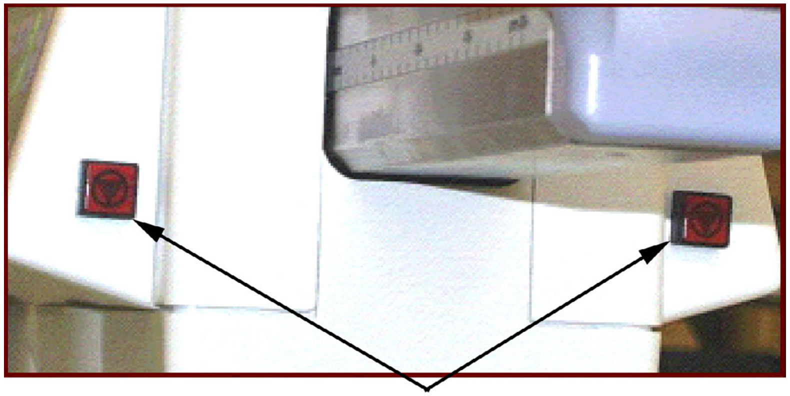
X-Ray On, X-Ray Disable

The Generator does not receive drive signals unless both X-ray Enable and X-ray ON are asserted. X-Ray Enable is generated by a hardware switch closure (top button, hand or footswitch), whereas X-Ray ON is generated by software. Both must be active to allow X-Ray generation, which prevents a single fault condition from allowing uncommanded X-rays.

Status of these lines is displayed at LED DS2 on the HV Supply Regulator PCB. LED XRE shows a hardware switch closure when lit and LED XRO shows when illuminated that software signal X-Ray ON is active.



X-Ray On Switch



Fast Stop Switches

Functional Tests

Perform the following tests to verify that the system is operating satisfactorily.

(Refer to the 9800 C-Arm Sub-system chapter of this manual for Functional Tests.)

1. System Boot
2. Make a fluoroscopic exposure.
3. Make a Film exposure

Fault Isolation

Failure	Possible Cause	Remedy
X-ray Switch	Bad switch	Make a fluoro exposure using the Handswitch or Footswitch. If system does not perform properly, Check the X-ray switch. Check Operation of Control Panel. Follow X-ray signal on Schematics.
No Exposure from Handswitch or Footswitch	Bad Handswitch or Footswitch	Make a fluoro exposure using the X-ray switch. If system does not perform properly, Check the Handswitch or Footswitch. Check Security, X-ray-On and X-ray Enable lines to ensure interlock not broken. Check ARCnet communications to X-Ray Controller PCB and Fluoro Functions PCB.
Bad Footswitch Mode Switch	PCB seating and cable connections	Make a mode change using the Handswitch. Check cabling and PCB seating.
X-ray Keyswitch	Keyswitch in wrong position or bad wiring/switch	Key must be in horizontal position to generate X-rays and operate column lift. Key in vertical position disables these functions.
Fast Stop Switches Inoperative	Bad Fast Stop Switches	Operate one Fast Stop Switch. Make sure X-ray tube stator stops and the Column does not go up or down. After reboot, make the same test using the other Fast Stop switch. If either switch fails to immediately stop the system, Check the switch module.

Adjustments

None.

Miscellaneous

Signal Names and Functions

X-Ray Controller PCB 00-879625

CHG_DISAB*	Input to Battery Charger, active low, CHGDISAB on Battery Charger PCB schematic, CHG_DISAB on Interconnect Diagram.
CHG_I_SEN	Analog output from Battery Charger, called CHGISEN.
HI_CHG_MOD	Input to Battery Charger, HICHGMOD. Requires limit resistor on Battery Charger.
LINE_V_SEN	Analog output, called LVOLTSEN on Battery Charger.
II_ON*	Open collector active low output to Pwr/Mtr Relay PCB, called II_ON there and on Interconnect Diagram.
CPU_INTERLOCK	Signal toggles continuously while CPU is running.
KEY_PWR	12V from Power Control PCB via pushbutton switch.
STATOR_RUN*	Signal from X-Ray Controller operates stator power relay.
STATOR_START*	Signal from X-Ray Controller operates stator voltage relay.
STATOR_SENSE	Senses stator current.
STATOR_SEN_RTN	Reference for above.
XRAY_ON*	Active low logic level controls X-ray pulse envelope.
XRAY_ENABLE*	Active low logic level controls X-ray production.
KVP_CNTL	Analog level controls kVp output of Generator. Not used on PCB.
KVP_CNTL_REF	Analog ground reference for KVP_CNTL. Not used on PCB.

SHUTDOWN	Logic level signal active high, disables generator
ANALOG_RTN	Analog direct ground return path for FIL_ERROR etc.
FIL_DRV_A*	Active low filament optocoupler drive signal (will be active high)
FIL_DRV_B*	Active low filament optocoupler drive signal (will be active high)
FIL_SELECT	Logic level selects large filament when high, small when low.
FAULT_RST	Logic high clears all fault latches on Generator Driver & HVSR.
FIL_B_CNTL	Analog filament supply regulator control signal
FIL_B_CNTL_REF	Analog ground reference for above, resistive termination.
HV_GEN_ON*	Logic level signal indicates presence of high voltage drive at tank
INTLK_CMPLT*	Logic level signal goes low when 24V_INTERLOCK is on.
FAULT	Active high logic level signal indicates a latched fault condition
OVER_KVP_FAULT	Active high latched logic level signal indicates overvoltage
GND_INTEG*	Active low logic level signal indicates ground connection to tank
FIL_DRV_OK*	Active low logic level signal indicates that filament current is present.
OVERLD_FAULT	Active high latched fault signal indicates overcurrent in HV transformer
SAT_FAULT	Active high latched logic signal indicates excessive saturation voltage on IGBTs
SM_FIL_ACK*	Low if small filament is selected.
INV_B_SEN	Analog signal senses battery voltage on filament supply
INV_B_SEN_REF	Analog ground reference for above, resistive termination
FIL_B_SEN	Analog signal senses filament regulator supply voltage
FIL_B_SEN_REF	Analog ground reference via resistor for above.
FIL_CUR	Analog signal representing true rms filament current
FIL_CUR_REF	Analog ground reference via resistor for above
FIL_VOLT	Analog signal representing true rms filament voltage
FIL_VOLT_REF	Analog ground reference via resistor for above.
FLUX_SEN	Analog signal representing kVp from flux in HV transformer.
FLUX_SEN_REF	Analog ground reference via resistor for above.
FIL_ERROR	Analog signal for error control of filament for fine control of mA.
+15V, POS_15V	DC +15V power.
-15V, NEG_15V	DC -15V power.

Digital Logic Signal Levels

Logic signals that are connected from one PCB assembly to another, for example, will assume TTL logic levels, i.e., logical low is ≤0.8V, and logical high is ≥2.0V (in most cases, ≥4.0V.)

Critical logic signals will be transmitted from one board to another using a pull-up resistor on the destination board, and typically none on the originating board, and will be so configured that in the event of an open-circuited connection, the high state input at the destination board will result in a safe condition, e.g., if the FAULT signal originating on the Generator Driver PCB is active high, and is configured to prevent X-ray generation at the destination HV Supply Regulator PCB, then absence of a connection will cause the destination PCB to fail safe and prevent generation of X-rays. Alternatively, absence of a connection from the collector of the transistor on the Filament Driver PCB which generates the GND_INTEG* signal, active low, will cause the pull-up resistor on the destination HV Supply Regulator PCB to pull up this line to a logic high level and disable X-ray production.

Specific examples of this rule are tabulated below. All PCBs are listed here even though some are not described within this section.

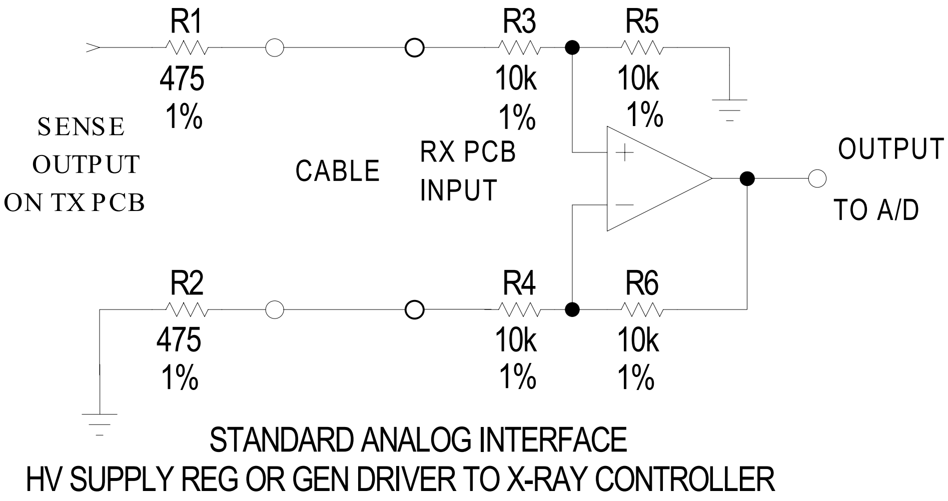
Signame	Source	Destination	Active	Pull-up	Effect of open fault
XRAY_ON*	XR Ctrlr	HV Sup Reg	L	Y	PWM chip disabled
		Gen Drvr	L	Y	Stops fault sensing
XRAY_ENABLE*	XR Ctrlr	HV Sup Reg	L	Y	Forces KVP_PULSE low
		Gen Drvr	L	Y	Disables kVp drivers
SHUTDOWN	XR Ctrlr	HV Sup Reg	H	Y	Disables KVP_DRV_RTN
		Gen Drvr	H	Y	Disables kVp drivers
ANALOG_RTN	XR Ctrlr	Gen Drvr	GND	N	Direct ground return
FIL_DRV_A*	XR Ctrlr	Gen Drvr	L	Y	No fil. drv, FIL_DR_OK* hi
FIL_DRV_B*	XR Ctrlr	Gen Drvr	L	Y	No fil. drv, FIL_DR_OK* hi
FIL_SELECT	XR Ctrlr	Fil Drvr	H	PD	Sm fil selected
FAULT_RST	XR Ctrlr	HV Sup Reg	H	PD	Does not reset faults
		Gen Drvr	H	PD	Does not reset faults
HV_GEN_ON*	Fil/Gen Drvr	XR Ctrlr	L	Y	Software input
INTLK_CMPLT*	Fil Drvr	HV Sup Reg	L	Y	Disables KVP_DRV_RTN
		Gen Drvr	L	N	Passes through

Signame	Source	Destination	Active	Pull-up	Effect of open fault
		XR Ctrlr	L	Y	Software input
FAULT	Gen Drvr	HV Sup Reg	H	Y	Disables KVP_DRV_RTN
		Gen Drvr	H	Y	Disables kVp drivers
OVER_KVP_FAULT	Gen Drvr	XR Ctrlr	H	Y	Software input
GND_INTEG*	Fil/Gen Drvr	HV Sup Reg	L	Y	Disables KVP_DRV_RTN
		XR Ctrlr	L	Y	Software input
		Gen Drvr	L	Y	LED off
FIL_DRV_OK*	Gen Drvr	HV Sup Reg	L	Y	Disables KVP_DRV_RTN
		XR Ctrlr	L	Y	Software input
OVERLD_FAULT	Gen Drvr	Gen Drvr	H	N	Sets FAULT high, dis. kVp
		XR Ctrlr	H	Y	Software input
SAT_FAULT	Gen Drvr	Gen Drvr	H	N	Sets FAULT high, dis. kVp
		XR Ctrlr	H	Y	Software input
SM_FIL_ACK*	Fil/Gen Drvr	XR Ctrlr	L	Y	Software input
HF_SYNC	XR Ctrlr	HV Sup Reg	T	N	Oscillator not synchronized
V_SLOW_RAMP	XR Ctrlr	HV Sup Reg	H	PD	Can’t select this or slower

Signame	**Source**	**Destination**	**Active**	**Pull-up**	**Effect of open fault**
FAST_RAMP*	XR Ctrlr	HV Sup Reg	L	Y	Cant select this speed
MA_HIGH*	HV Sup Reg	XR Ctrlr	L	Y	False ind. of high mA
MOD_READY	HV Sup Reg	XR Ctrlr	H	Y	Can’t check modulator stat

Standard Interface Analog Signal Levels

In most cases, analog signals will be transmitted and received differentially, using the following standard interface, as shown in the schematic below.


R1
475
1%
R2
475
1%
SENSE
OUTPUT
ON TX PCB
CABLE
RX PCB
INPUT
R3
10k
1%
R4
10k
1%
R5
10k
1%
R6
10k
1%
+
−
OUTPUT
TO A/D
STANDARD ANALOG INTERFACE
HV SUPPLY REG OR GEN DRIVER TO X-RAY CONTROLLER

Standard Analog Interface Schematic

kV Generation

Circuit/Mechanical Descriptions **2**
Functional Tests **6**
Fault Isolation **6**
Adjustments **8**
  kVp Accuracy 8
Miscellaneous **9**
 Signal Names and Functions 13
  X-Ray Controller PCB 13
  High Voltage Supply Regulator 13
  Generator Driver PCB 14
  IGBT/Snubber Assembly 15
  Capacitor/Power Module 15

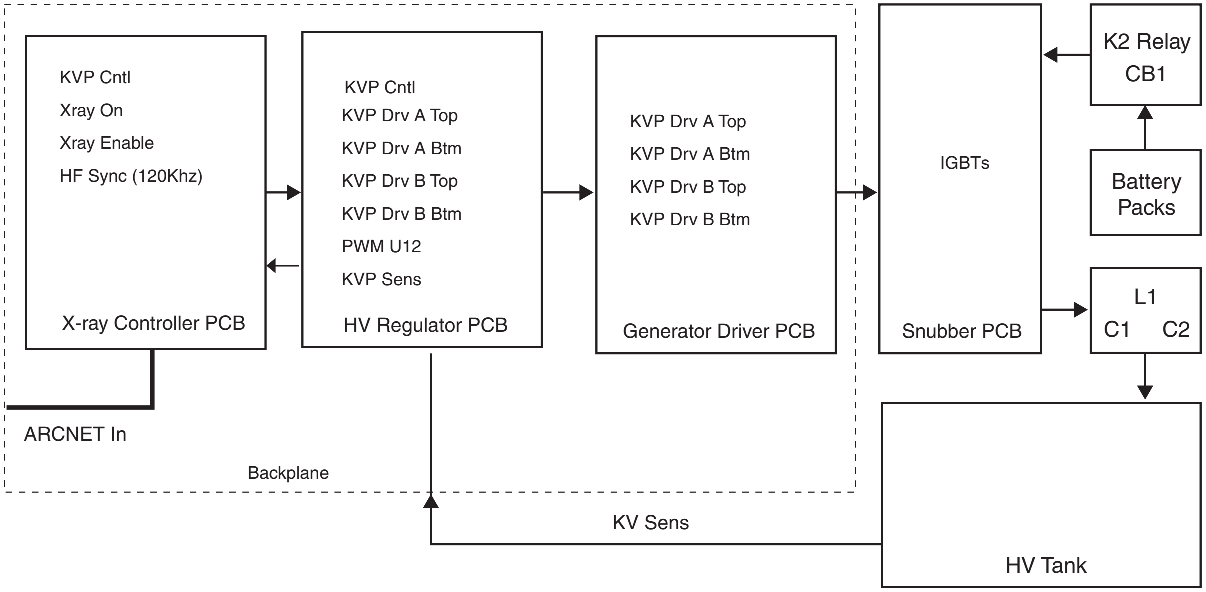
Circuit/Mechanical Descriptions

The kV generation and control for the system is accomplished on four PCB cards and the High Voltage Tank. The kV value is sensed in the tank and fed back to the HV Regulator PCB to modify and stabilize the drive to the section. The battery bank supplies the high current needed by the tank to generate the high voltage for the X-ray tube anode. The reservoir capacitors allow the high ripple current generated by the switching of the IGBTs to bypass the battery.

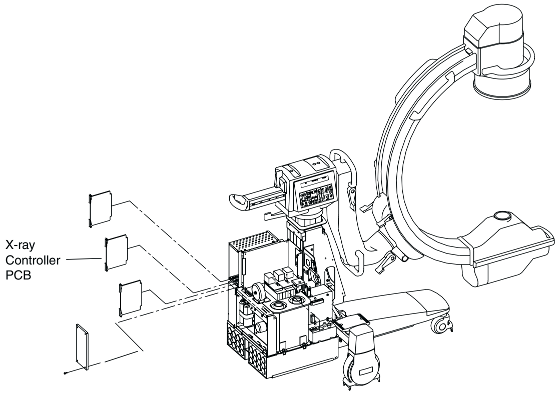
The microprocessor on the X-Ray Controller PCB triggers kV generation on commands received from the Control Panel Processor and Fluoro Functions PCB via ARCNET. The X-ray Controller PCB supplies an analog voltage to the HV Regulator PCB to control the kV voltage required. The XRAY_ENABLE signal allows X-rays to be generated and the XRAY_ON signal switches a control signal through circuitry on the HV Regulator PCB to adjust the kVP waveform rise time. These two signals are generated when the X-ray button or the hand switch or foot switch buttons are depressed to make X-rays.

The output of the HV Regulator PCB is combined with output of a sense circuit from the High Voltage Tank. The signals, equal amplitude and opposite polarity, are used by the HV Regulator PCB to regulate the output of the Generator Driver PCB to the Insulated Gate Bipolar Transistors (IGBTs) on the Snubber PCB.

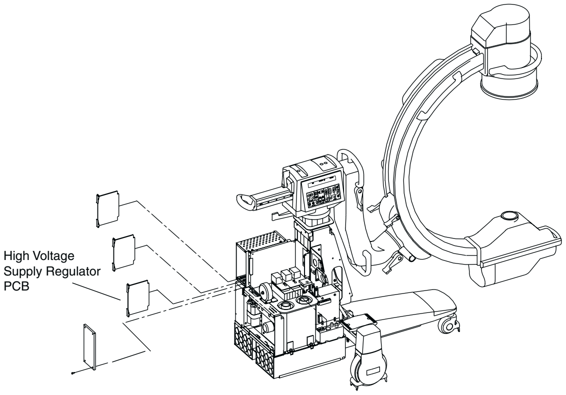
The B+ from battery packs is applied to the bus all the time after precharging is completed. IGBTs Q1 and Q2 drive the HV Tank step-up transformer through the series tuned circuit formed by L1, C1 and C2.


KVP Cntl
Xray On
Xray Enable
HF Sync (120Khz)
X-ray Controller PCB
KVP Cntl
KVP Drv A Top
KVP Drv A Btm
KVP Drv B Top
KVP Drv B Btm
PWM U12
KVP Sens
HV Regulator PCB
KVP Drv A Top
KVP Drv A Btm
KVP Drv B Top
KVP Drv B Btm
Generator Driver PCB
IGBTs
Snubber PCB
K2 Relay
CB1
Battery
Packs
L1
C1
C2
ARCNET In
Backplane
KV Sens
HV Tank

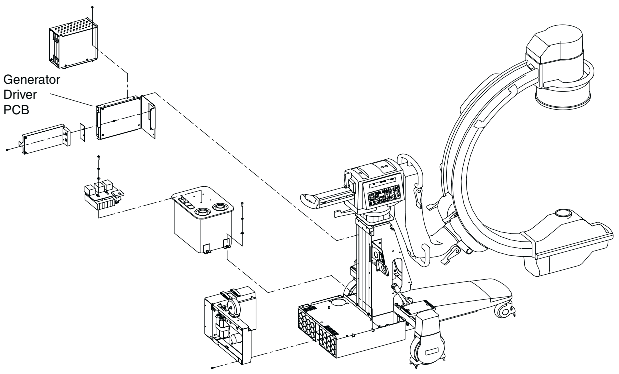
kV Generation


X-ray
Controller
PCB

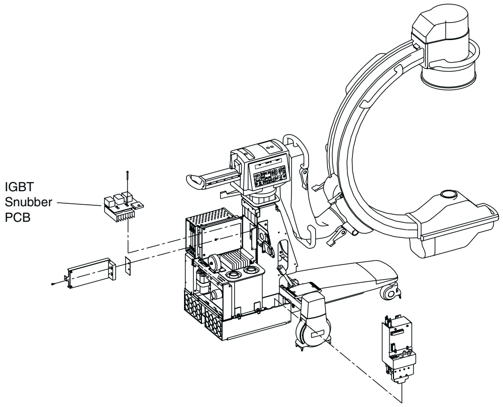
X-Ray Controller PCB Location


High Voltage
Supply Regulator
PCB

High Voltage Supply Regulator PCB Location


Generator
Driver
PCB

Generator Driver PCB Location


IGBT
Snubber
PCB

IGBT Snubber Location

PCB locations

Additional circuitry in the HV Tank allows the Filament Driver and Generator Driver to sense the flux in the HV Transformer and confirm that the generator is on (HV_GEN_ON*.) Another circuit confirms that the flux is generating the right kV level (FLUX_SEN) so that possible faults can be detected, including overvoltage (OVER_KVP_FAULT). The voltage across the lower IGBTs is sensed to detect saturation faults (SAT_FAULT). Excessive current in the series tuning components will generate an overload fault (OVERLD_FAULT). These fault signals are combined to drive a latch (FAULT, FAULT_LATCH) which can be reset by software under some circumstances (FAULT_RST) or in others, software will positively shut down the kV generation (SHUTDOWN).

An HF_SYNC signal from the X-Ray Controller accurately synchronizes the PWM kV generation to the correct operating frequency. Two other signals control the pulse shape and rise time at different mA levels.

Functional Tests

Make a Fluoro exposure and observe the kV readout on the control panel. The readout should remain steady on the desired kV technique.

Perform the following tests to verify that the system is operating satisfactorily.

(Refer to the *9800 C-Arm Sub-system* chapter of this manual for Functional Tests.)

1. System Boot
2. Make a fluoroscopic exposure.
3. Make a film exposure

Fault Isolation

WARNING: *Dangerous voltages are present when covers are removed from the system and when x-ray exposures are made.*

Failure	Possible Cause	Remedy
Fluoro exposure technique fluctuates or exhibits other abnormalities	ABS not working, Video Level unstable	Check the output connections from the Snubber PCB to the IGBTs during a Fluoro exposure. Using an extender card and oscilloscope, check the various KVP control signals to determine which PCB may be faulty.

Failure	Possible Cause	Remedy
No Image and kV tracks to 120.	Anything in the kV generation circuit or Image path.	Check the FLUX_SEN on the Generator Driver or X-Ray Controller to see if the flux is unstable and varying from the nominal value This is more often a software problem, but can arise from a filament failure or the system not coming out of “sleep” mode when it should. Try making manual exposures at low technique values, which should give some output.
Various Errors	Peak voltages on IGBT’s could exceed ratings and cause early failure. Snubber components damaged or defective.	The capacitors are rated for at least 400V. The current ratings are also adequate for this duty. If any of these components fail, the high voltage supply to the PCB is protected by a fuse, and if this fuse blows, the Filament Driver PCB will not operate. An open failure could result in larger voltages occurring at the outputs, but there is also a snubber across the supply at Q2 which will tend to prevent this condition.

Adjustments

For details of these adjustments, refer to the *Calibration* chapter in this manual.

1. Stability Adjustment, HV Supply Regulator PCB, TP48, Pot R83.
2. Dead Time Adjustments, HV Supply Regulator PCB, TP70-71, 41-46, Pots R137, R84. If the condition of the dead time adjustment is not known, turn pots 10 turns clockwise to the safe position.
3. Sync Adjust, HV Supply Regulator PCB, Pot R139.
4. Ramp Adjust, HV Supply Regulator PCB, Pot R109, TP57.

kVp Accuracy

1. Set the generator to produce a 100kVp nominal technique setting. This should result in a voltage at the X-Ray Controller's DAC of 6.5934V. This will be reduced to 6.4423V between KVP_CNTL and KVP_CNTL_REF at the HV Supply Regulator PCB. The mA setting should be 0.2mA.
2. Verify the output voltage at TP25, KVP_CNTL_TP to be 6.5596V ± 2%.
3. The KVP_PULSE* voltage at TP19 should be -6.5577V ± 2%.
4. The KVP_SEN_TP voltage at TP21 should be 6.5906V ± 2%.
5. The kVp value measured should be 100kVp ± 3%.

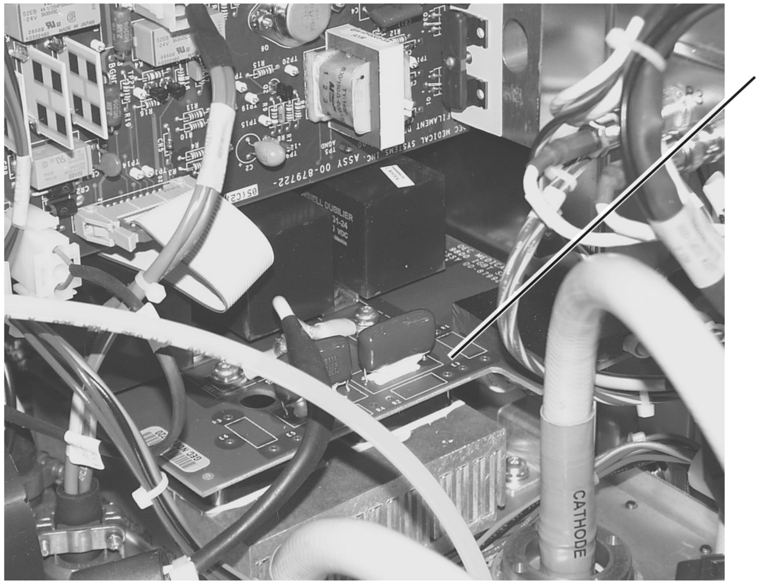
Note: *Non-invasive kVp meters will generally give inaccurate readings because of the level of filtering in the 9800 system and various other factors. Measurement is generally better at higher mA values, e.g. above 3mA. Although we do not typically use Dynalyzers in the field, we have confirmed that the actual kVp developed is typically within 1kV of the selected value, while non-invasive meters range from –15% to +10% of the correct kVp especially at low mA techniques. They also tend to give inconsistent results when placed at different locations in the X-ray beam.*

Miscellaneous

WARNING: *High Voltage Hazard: Be sure to short the capacitors of the Capacitor/Power Module to ground through a current-limiting resistance before testing either the capacitors or bleeder resistors.*

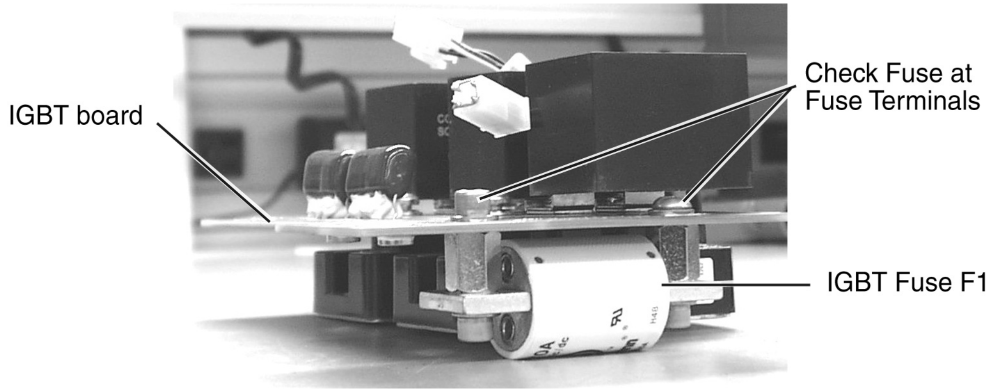
Snubber PCB Fuse F1 (70A @ 250 V) is located under the Snubber PCB. The whole assembly should be replaced, not just the fuse. This requires removal and replacement of the Filament Driver PCB cover and PCB, and the IGBT/Snubber Asm. The fuse can be checked from the fuse terminals on the top of the Snubber PCB Dead time adjustments will be necessary after replacement.

Before powering up the system after such a replacement, the dead time adjustments need to be set fully clockwise to maximum and all wiring to the tank checked for shorts to ground, etc. The dead time adjustments must then be done by a qualified service person.



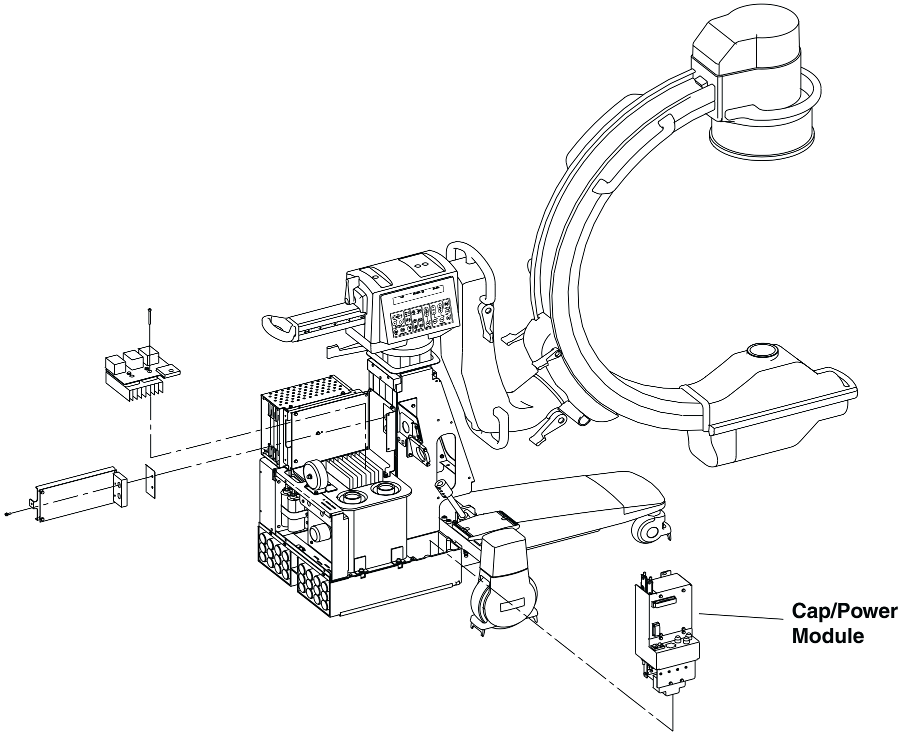
Location
of
IGBT PCB

Location of IGBT PCB


IGBT board
Check Fuse at
Fuse Terminals
IGBT Fuse F1

IGBT PCB Removed for Clarity

A bank of three 6800uF, 300V capacitors (C8-C10) are located in the Capacitor/Power Module. They supply large amounts of current for short periods. These capacitors are connected to four 1K, 25-watt resistors in parallel to bleed dangerous voltages from the high-energy capacitors when the system is shut down because of a fault.


Cap/Power
Module

Cap/Power Module Location

Signal Names and Functions

X-Ray Controller PCB

(See X-Ray On, X-ray Disable section.)

High Voltage Supply Regulator

KVP_SEN	Analog signal represents kVp output from tank voltage divider.
KVP_SEN_REF	Ground reference for above through resistor.
HF_SYNC	120kHz squarewave to synchronize PWM oscillator, via B/P
V_SLOW_RAMP	Ramp control signal, via backplane. Controls pulse shape.
FAST_RAMP*	Ramp control signal, via backplane. Controls pulse shape.
MOD_READY	+5V from internal regulator in PWM chip, goes low on fault
KVP_SEN_POS	From kVp sense voltage divider in tank, A9P2/J2 to Backplane A1P3/J3, positive going sense line of pair.
KVP_SEN_NEG	From kVp sense voltage divider in tank, A9P2/J2 to Backplane A1P3/J3, negative going sense line of pair.
CBL_SHLD	Shields of the above three twisted pairs, connected to tank chassis and to chassis ground at Backplane via cable asm 00-879454-XX.
XRAY_ON*	Active low logic level controls X-ray pulse envelope.
XRAY_ENABLE*	Active low logic level controls X-ray production.
KVP_CNTL	Analog level controls kVp output of Generator.
KVP_CNTL_REF	Analog ground reference for KVP_CNTL..
KVP_DRV_A_TOP	Optocoupler drive signal for IGBT Q1 upper gate G1.
KVP_DRV_A_BTM	Optocoupler drive signal for IGBT Q1 lower gate G2.
KVP_DRV_B_TOP	Optocoupler drive signal for IGBT Q2 upper gate G1.
KVP_DRV_B_BTM	Optocoupler drive signal for IGBT Q2 lower gate G2.
KVP_DRV_RTN	Optocoupler return current path, enabled or disabled by faults.
SHUTDOWN	Logic level signal active high, disables generator
ANALOG_RTN	Analog direct ground return path for FIL_ERROR etc.
FAULT_RST	Logic high clears all fault latches on Generator Driver & HVSR.
FAULT	Active high logic level signal indicates a latched fault condition
GND_INTEG*	Active low logic level signal indicates ground connection to tank

24V_INTERLOCK	Positive 24V from Power/Motor Relay PCB A4P7/J7 to Power/Signal Interface PCB A11J8/P8 and from A11P3/J3 to Battery Charger PCB A22J2/P2, then from A22P3/J3 to Backplane A1J4/P4, thence to HV Supply Regulator PCB A1A1. Also from A11P10/J10 to Generator Driver PCB A2J2/P2 and from A2P5/J5 to Filament Driver PCB A21J1/P1. This signal is used to generate INTLK_CMPLT*.

Generator Driver PCB

XRAY_ON*	Active low logic level controls X-ray pulse envelope.
XRAY_ENABLE*	Active low logic level controls X-ray production.
KVP_DRV_A_TOP	Opto-coupler drive signal for IGBT Q1 upper gate G1.
KVP_DRV_A_BTM	Opto-coupler drive signal for IGBT Q1 lower gate G2.
KVP_DRV_B_TOP	Opto-coupler drive signal for IGBT Q2 upper gate G1.
KVP_DRV_B_BTM	Opto-coupler drive signal for IGBT Q2 lower gate G2.
KVP_DRV_RTN	Opto-coupler return current path, enabled or disabled by faults.
SHUTDOWN	Logic level signal active high, disables generator
ANALOG_RTN	Analog direct ground return path for FIL_ERROR etc.
FAULT_RST	Logic high clears all fault latches on Generator Driver & HVSR.
HV_GEN_ON*	Logic level signal indicates presence of high voltage drive at tank
FAULT	Active high logic level signal indicates a latched fault condition
OVER_KVP_FAULT	Active high latched logic level signal indicates overvoltage
GND_INTEG*	Active low logic level signal indicates ground connection to tank
OVERLD_FAULT	Active high latched fault signal indicates overcurrent in HV transformer
SAT_FAULT	Active high latched logic signal indicates excessive saturation voltage on IGBTs
INV_B_SEN	Analog signal senses battery voltage on filament supply
INV_B_SEN_REF	Analog ground reference for above, resistive termination
FLUX_SEN	Analog signal representing kVp from flux in HV transformer.
FLUX_SEN_REF	Analog ground reference via resistor for above.
+15V, POS_15V	DC +15V power.
-15V, NEG_15V	DC -15V power.
DC_COMMON	Analog and Digital ground (2 lines). These may be removed to isolate a ground loop. Called GND on Generator Driver PCB.
+5V, POS_5V	DC +5V power.
24V_INTERLOCK	DC +24V power via interlock relay (no longer used on PCB).

IGBT/Snubber Assembly

CAP_POS	Capacitor C8 positive via wire and ferrite bead to upper collectors of IGBT’s.
CAP_NEG	Lower emitters of Q1, Q2 via wire and ferrite bead to ground at C8.
Q1G1	Upper gate of Q1 to Generator Driver PCB at A2J3/P3.
Q1E1	Upper emitter of Q1 to Generator Driver PCB at A2J3/P3.
Q1G2	Lower gate of Q1 to Generator Driver PCB at A2J3/P3.
Q1E2	Lower emitter of Q1 to Generator Driver PCB at A2J3/P3.
Q2G1	Upper gate of Q2 to Generator Driver PCB at A2J4/P4.
Q2E1	Upper emitter of Q2 to Generator Driver PCB at A2J4/P4.
Q2G2	Lower emitter of Q2 to Generator Driver PCB at A2J4/P4.
Q1E1_C2_L1	Output of Q1 to L1.
Q2E1_C2_L1	Output of Q2 to L1.

Capacitor/Power Module

CAP_NEG	Battery negative from CB1 to chassis ground at negative of C8, and to Filament Driver PCB.
CAP_POS	Capacitor C8 positive via wire and ferrite bead to upper collectors of IGBT’s Q1, Q2.
CAP_NEG	Lower emitters of Q1, Q2 via wire and ferrite bead to ground at C8 and separately to Filament Driver PCB.
K2P_F4	Battery positive from K2 pole to fuse F4.

mA Generation

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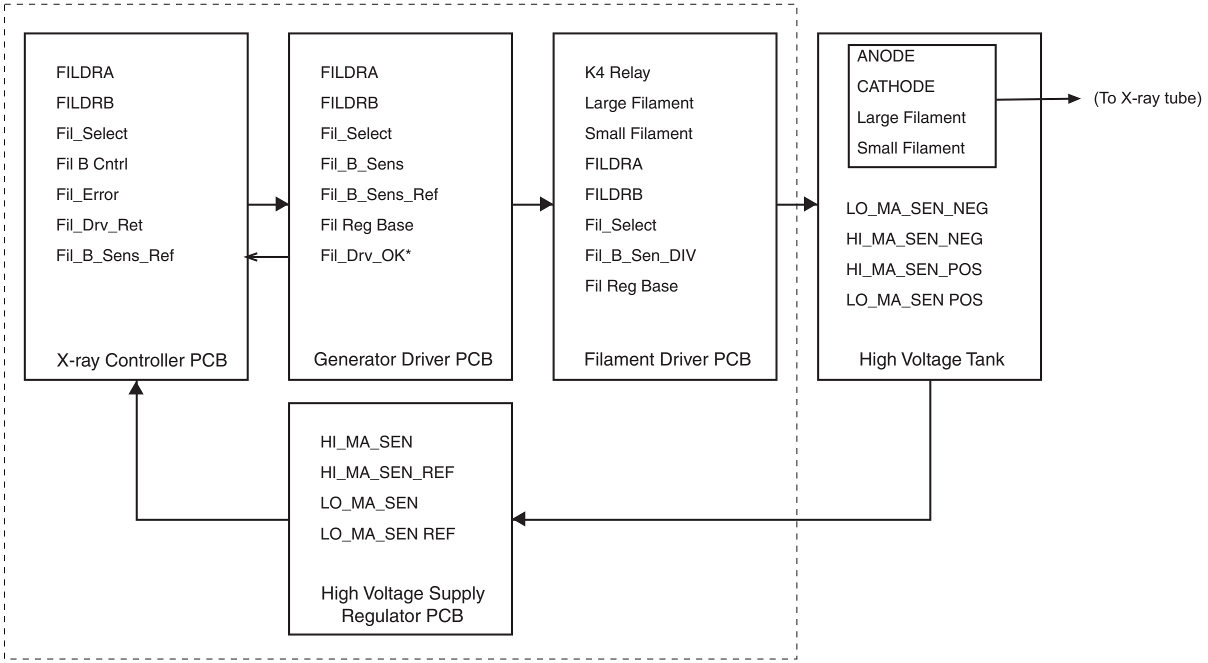
Circuit/Mechanical Descriptions

mA generation and regulation is accomplished with four printed circuit cards, with feedback from the High Voltage Tank. Prior to X-ray generation, the initial technique is setup, i.e., filament, select, kV, and mA. The correct filament selection is output to a relay on the Filament Driver PCB, and the correct FILAMENT SUPPLY voltage set up. Filament drive is provided from the X-Ray Controller PCB to the optocouplers on the Generator Driver PCB. The optocouplers isolate the filament drive signals and in turn, drive to the Filament Driver PCB through a coupling transformer. The transformer output drives a pair of MOSFETs that drive the selected filament transformer in the high voltage tank.

The amplitude of the filament drive is regulated on the Filament Drive PCB by changing the output stage supply voltage FIL_B_PLUS. The measured mA is compared with the commanded mA in the X-ray Controller to generate the FIL_ERROR signal. The FIL_B_CNTL signal is set up by the X-Ray Controller to make the Filament Driver PCB supply voltage 160V for the small filament and 140V for the large filament. . FIL_B_SEN is compared with the FIL_B_CNTL and FIL_ERROR voltages to adjust FIL_REG_BASE so that the FIL_B_PLUS varies ±5V to control the mA. This circuitry is split between the Generator Driver and Filament Driver PCBs.


FILDRA
FILDRB
Fil_Select
Fil B Cntrl
Fil_Error
Fil_Drv_Ret
Fil_B_Sens_Ref
X-ray Controller PCB
FILDRA
FILDRB
Fil_Select
Fil_B_Sens
Fil_B_Sens_Ref
Fil Reg Base
Fil_Drv_OK*
Generator Driver PCB
K4 Relay
Large Filament
Small Filament
FILDRA
FILDRB
Fil_Select
Fil_B_Sen_DIV
Fil Reg Base
Filament Driver PCB
ANODE
CATHODE
Large Filament
Small Filament
(To X-ray tube)
LO_MA_SEN_NEG
HI_MA_SEN_NEG
HI_MA_SEN_POS
LO_MA_SEN POS
High Voltage Tank
HI_MA_SEN
HI_MA_SEN_REF
LO_MA_SEN
LO_MA_SEN REF
High Voltage Supply Regulator PCB

mA Generation

The FIL_ERROR voltage is actively controlled by the microprocessor on the X-Ray Controller PCB to adjust the filament voltage controlling the actual tube mA during a shot. The pulse width does not change. The small feedback loop change provides a safeguard to the x-ray tube and guards against improper operation that could result in an x-ray hazard.

The circuitry on the Generator Driver PCB monitors the filament current and pulls a control voltage low if the filament current exceeds the sleep mode value. Absence of either drive will reduce filament current to a very low value. This prevents generation of X-rays by turning off the kVp drive at the High Voltage Supply Regulator PCB, with the signal FIL_DRV_OK*. When a shot has to be made after the generator has been in sleep mode, a delay is necessary to allow the filament to warm up to the correct temperature.

The Generator Driver PCB monitors both the filament voltage and filament current from voltages present on the Filament Driver PCB. The. filament selection relay generates another signal to the Generator Driver PCB to control the gain of the measurement circuits, because the two filament transformer ratios are different.

The actual filament voltage and current measurements are relayed through the Generator Driver PCB to the X-Ray Controller PCB from the tank. There analog voltages are converted to digital and fed to the microprocessor for control of the Filament Driver PCB.

Functional Tests

X-ray Tube

None—Refer to the Fault Isolation chart for the X-ray Tube, later in this chapter.

High Voltage Tank

If you suspect the tank may be faulty, make the tests detailed in the Fault Isolation section and check for internal arcing and carbon trails in the connectors. Do not open up the tank.

mA Accuracy

Note: These tests can only be accomplished using a complete C-arm system with functional system software, as the image chain must be operational.

1. Place lead sheet over the Image Intensifier.
2. Using techniques from 40kVp at 0.2mA up to 100kVp at 40mA, in suitable increments, verify that mA is within C-Arm requirements for this range. Refer to the *Calibration* chapter of this manual for details.
3. Using high mA pulsed techniques from 40kVp at 20mA to 120kVp at 125mA, in suitable increments, verify that mA accuracy is within ±10%. Refer to the *Calibration* chapter of this manual for details.

Note: These tests may heat the X-ray tube up. Observe all temperature warnings and allow to cool when necessary to avoid damage to the X-ray tube.

WARNING: *Dangerous voltages are present when covers are removed from the C-Arm. These tests generate X-rays. Take appropriate precautions.*

Depending on the type of failure check any of the following:

Filament Test

To test the small and large filaments, perform the following exposures:

1. Take a 70 kV @ 20 mAs film exposure. If the processed film is dark and under-exposed the small filament may be faulty.
2. Take a 100 kV @ 300 mAs film exposure. If the processed film is dark and under-exposed the large filament may be faulty.

Fault Isolation

This section provides troubleshooting information about the X-ray Tube, High Voltage Tank, and mA generation.

X-ray Tube

Failure	Possible Cause	Remedy
System shuts down with no error messages	Inappropriate activation of thermal switch	Troubleshoot cooling function (see *Cooling* chapter in this manual*).*
Arcing	Candlesticks and wells	Check Candlesticks and wells for black carbon trails

High Voltage Tank

WARNING: *Dangerous voltages are present when covers are removed from the C-Arm.*

Failure	Possible Cause	Remedy
Low mA messages	High Voltage Tank	Use the schematic diagram and an ohmmeter to verify the resistance of the 10 ohm, 15 ohm and 24k ohm resistors inside of the tank. Note that the 400 M ohm resistors cannot be checked.
Overvoltage messages	High Voltage Tank	(See above)
Arcing	Carbon trails on candlesticks	Take an exposure at 120 kVp and listen for internal arcing between a High Voltage point and the case.

Failure	**Possible Cause**	**Remedy**
X-Ray Tube overheats - Sensor indicates high temperature, or thermal cutout operates.	Overuse of X-ray generation, failure of anode rotation, stator at wrong voltage.	The stator voltage is defined by the transformer as 40V and current is sensed by STATOR_SEN, which software determines to be in the correct range. It is possible to sense a stalled rotor. The housing temperature sensor is an improved type with less likelihood of failure due to ESD. Actuation of the thermal cutout indicates gross over-temperature and should not happen if software is correctly computing anode temperature and monitoring housing temperature. Failure of the housing temperature sensor is detected by observation that its output changes as the housing heats and cools, and comparison with a room temperature benchmark at boot-up, if sufficient time has elapsed since last procedure.
Excessive temperature at tank	Oil expansion beyond set limits, IGBT failure. Failure or disconnection of cooling fan	With the cooling fan operating, the heat sink limits temperature of the tank to about +30°C rise above external ambient for continuous fluoro at 100kVp, 1mA for three hours. With the fan disconnected, the IGBT heat sink gets hotter, reaching 70°C in about two hours. These limits are considered satisfactory for the system, as this type of use is typically rare. Most procedures do not generate as much heat for as long a time. Oil expansion issues are mitigated by provision of an expansion chamber connected to the tank.

mA Generation

Failure	Possible Cause	Remedy
Filament drive pulses absent	With either filament drive pulse absent, the Filament Driver PCB produces no drive and the X-ray tube cannot produce x-rays. If only one drive is present, the filament drive circuitry does not operate properly. One FET will be always off, so no filament drive occurs. Application of high voltage to the X-ray tube without filament drive might cause a hazard, as the tube cannot discharge it. Optoisolators faulty, broken connections, no FIL_DRV_RTN connection, fault in 7407, faulty 74LS14, fault in FIL_CUR sensor.	A detection circuit on the Generator Driver PCB looks for the presence of filament current above that in sleep mode. If either or both pulses are missing, there's no filament current and the signal FIL_DRV_OK* goes high, indicating this condition to the X-Ray Controller PCB. The software monitors this signal before enabling X-ray production. If FIL_DRV_OK* is high, or is disconnected from the card cage, the HV Supply Regulator disables kVp drive and prevents X-ray production. If pulses are present at the Generator Driver, but not getting to the Filament Driver PCB, or if there is a fault on that PCB, absence of a filament voltage at FIL_VOLT_DIV causes FIL_VOLT to be zero. If there is filament voltage, but no current, FIL_CUR is zero. These two signals also return to the X-Ray Controller PCB and are monitored by software to detect incorrect drive voltage and current for the duty ratio and filament selected. The FIL_DRV_OK* signal is produced by comparing FIL_CUR on the Generator Driver PCB with a fixed voltage representing a current higher than that in the sleep mode.

Failure	Possible Cause	Remedy
No filament voltage observed	Filament voltage at FIL_VOLT on Generator Driver PCB is zero. No FIL_B_PLUS voltage – Resistors open, cable problem. No FIL_B_PLUS - transistor open, capacitor short. No filament drive signals present. Faulty or shorted filament voltage sense resistors. Failure of filament voltage sensor at Generator Drive PCB. Broken connection to X-Ray Controller PCB. Failure at X-Ray Controller PCB.	Filament voltage is monitored by a sensing circuit on the Generator Driver PCB, and sends an analog signal to the X-Ray Controller PCB. This signal verifies that the filament voltage is in the expected range for the selected filament and technique, before the shot is initiated. The fault indicates a drive failure, a supply failure, a sensor failure or an interconnection failure. The INV_B_SEN line provides an analog signal to the X-Ray Controller PCB and is monitored by software. Additionally, the FIL_B_SEN line is monitored by software. If there is no drive, FIL_DRV_OK* on the Generator Driver PCB is high, as there will be no filament current sensor output at FIL_CUR on the Generator Driver. Absence of filament voltage at the tube prevents X-ray generation.
Filament Voltage Error	If the wrong voltage is applied to the filament, the mA will also be wrong. Filament B plus wrong, duty ratio of filament drive pulses wrong, wrong filament selected, failure of filament regulation, sensor gain wrong.	Filament voltage is monitored by an RMS to DC converter on the Generator Driver PCB, and fed to the Filament Driver PCB. If the wrong voltage occurs at FIL_VOLT relative to FIL_VOLT_REF, this is observed by the X-Ray Controller PCB. A fault in the RMS converter or the cable from the Filament Driver PCB might also result in the wrong voltage at FIL_VOLT, but there is also a filament current sense circuit, which will confirm the error. If there is an incorrect gain, this could be caused by the wrong filament relay selection or a problem in the relay which is on the Filament Driver PCB, but if the wrong filament selection is made, the SM_FIL_ACK* signal will be in the wrong state. Additionally, the mA is sensed on the HV Supply Regulator PCB, providing an independent check on the correctness of the filament drive. Other faults in the Filament Driver PCB such as wrong FIL_B_PLUS voltage are also monitored by software.

Failure	**Possible Cause**	**Remedy**
Wrong filament voltage observed	Filament current may be wrong, so mA generated will be wrong. Incorrect FIL_B_ PLUS voltage - filament control fault. INV_B_PLUS voltage low - battery charge problem. Faulty or disconnected filament voltage sense resistor. Incorrect filament selected, changing gain of voltage sensor.	Filament voltage is monitored by a true rms sensing circuit on the Generator Driver PCB which sends an analog signal to the X-Ray Controller PCB. This signal is monitored by software to verify that the filament voltage is in the expected range for the selected filament and technique, before the shot is initiated. Filament current is similarly monitored. Faults in the filament voltage regulator would affect INV_B_SEN or FIL_B_SEN signals. Incorrect filament selection would be seen through SM_FIL_ACK*, and further mitigation is provided by monitoring the filament current FIL_CUR in software to see if it is in the expected range for the voltage applied to the selected filament. Software also checks the INV_B_SEN and FIL_B_SEN signals to verify correct supply voltages.
No filament current (filament voltage present)	If the connector is disconnected or a filament drive wire is broken, the filament is not heated and no X-rays can occur. If the filament sense circuit is faulty, there could be normal filament current. P3 disconnected from Filament Driver PCB. P1 disconnected from tank A9J1. Broken connection in cable to tank. Filament current sense circuit fault.	If the connector at either end is disconnected, no filament drive reachs the filament, and in addition, X-ray generation is actively disabled by hardware operating on the TANK_CHAS line. Therefore, the failure results in a safe condition, but the system is inoperable. If the filament current is actually present, but a fault in the filament current sensor results in zero output, generation of kVp could result in normal mA; therefore, kVp should be applied with caution to verify that mA is correct. If filament current occurs with one filament only, a broken wire is likely. Operation could continue with the filament that is working correctly.

Failure	Possible Cause	Remedy
Wrong filament current observed (when voltage correct)	If filament current is wrong, mA generated may be wrong. Incorrect filament selected, changing gain of current sensor. Faulty filament current sense resistor. Filament regulator faults. Tube aging.	Filament current is monitored by a true rms sensing circuit on the Generator Driver PCB. The circuit sends an analog signal FIL_CUR to the X-Ray Controller PCB. This signal is monitored by software to verify that the filament current is in the expected range for the selected filament and technique, before the shot is initiated. Filament voltage FIL_VOLT is similarly monitored. A signal SM_FIL_ACK* is also generated by the filament selection relay so that the relay operation can be verified by software. Filament B+ is monitored by software via FIL_B_SEN and should be in the correct range of either about 160V or about 140V, depending on the filament selected. Inverter B+ is also monitored via INV_B_SEN, and is checked to verify its presence at the Filament Driver, and that the battery voltage is in its proper operational range. Further mitigation is provided by mA correction during the shot. If aging results in the wrong filament current, mitigation is provided by logging the gradual change in filament characteristics since the last calibration.
Filament current error	If filament current is wrong, then mA could be wrong. Filament aging, wrong filament selected, broken connection, current sense gain wrong.	Assuming that the filament voltage is correct, a wrong filament current reading could be caused by filament aging, wrong filament selection, wrong filament current sensing gain, other faults on the filament current sense circuit, errors at the X-Ray Controller PCB, or disconnections of interconnecting cables. Software monitors the effects of aging to determine if a gradual change is occurring. In any case, the ABS system will compensate for this effect. If the wrong filament is selected, the SM_FIL_ACK* signal is monitored to determine correct operation of the relay. Incorrect gain could be caused by failure of a relay contact, but this is very unlikely. A disconnection would probably result in failure to monitor the current. If the mA sensor on the HV Supply Regulator is working, software might determine that X-ray production could continue without accurate verification of filament current, since the ABS system would tend to correct any mA error.

Failure	Possible Cause	Remedy
Wrong filament selection	Filament voltage and current will be wrong. Disconnection of FIL_SELECT or 24V_INTERLOCK lines, bad transistor on Filament Driver PCB.	No mitigation on the Generator Driver PCB. The signal passes through to the Filament Driver PCB. Absence of this signal usually results in a safe condition, as the filament selection relay is in the relaxed position, selecting the small filament. Software monitors the SM_FIL_ACK* line before attempting to drive the generator at a technique only available with the large filament. ABS also adjusts the technique to the correct level in most cases.
Filament supply voltage wrong	Wrong filament voltage, inability to produce correct filament voltage. Bad filament supply regulator, filament voltage sense divider or sensor, wrong filament selected, wrong duty ratio of drive pulses.	If there is a small error, software on the X-Ray Controller determines the filament pulse duty ratio needed to compensate for it, before making X-rays. A gross error indicates a malfunction in the filament supply regulator, part of which is on the Filament Driver PCB. An apparent error could also be caused by a fault in the divider feeding the FIL_B_SN_DIV signal to this PCB. The FIL_B_SEN voltage is monitored at the X-Ray Controller PCB to verify that regulation is working, as set up by FIL_B_CNTL and FIL_ERROR. This is done before generating X-rays. If the filament supply voltage is high, there could be a fault in the output stage on the Filament Driver PCB, but software may be able to provide a temporary work around of this problem by varying the duty ratio accordingly.
Wrong mA during shot	Improper exposure (too high or too low). Patient dose rate wrong. Incorrect filament selected. Faulty mA sense circuit. Tube aging. kVp wrong.	Automatic brightness control (ABS) will adjust kVp and mA to match the desired shot, if the filament regulator is working. Software verifies correct kVp by use of FLUX_SEN. If the wrong filament is selected, it may still be possible to get a usable picture. Effect on patient dose will be at least partially mitigated by use of ABS. If the filament regulator has a gross failure, software can still determine the actual mA and kVp and use the SHUTDOWN signal to disable X-ray production. If there is a fault in either of the two mA sensors, crosschecking between them can be verified in software at low (fluoro) levels. If the MA_HIGH* line goes low when the mA is supposed to be under 14mA, it may indicate a fault in one of the mA sensors. If the kVp sensor has failed, the FLUX_SEN line provides a check on the actual kVp delivered to the tube, independent of the tank voltage dividers. With all of these factors, software will determine whether there is a safety issue and issue a warning or operate the SHUTDOWN line accordingly.

Adjustments

High Voltage Regulator PCB, Offset, Pot R126, TP42-40; Offset, R138, TP43-39; Differentiator, R63, TP31. For details, refer to the *Calibration* section of this manual.

Miscellaneous

Signal Names and Functions

HVPRI1	C1 to HV tank primary terminal E1.
HVPRI2	C2 to HV tank primary terminal E2.
LG_FIL	Large filament transformer input A9J1/P1. From Filament Driver PCB A21P3/J3.
SM_FIL	Small filament transformer input A9J1/P1. From Filament Driver PCB A21P3/J3.
FIL_RTN	Filament transformer common return from A9J1/P1 to Filament Driver PCB A21P3/J3.
KVP_FLUX_SEN	Single turn winding on HV transformer for sensing flux, from A9J1/P1 to Filament Driver PCB A21P3/J3.
TNK_CHAS	Tank chassis ground. Also return for single turn winding (which is the electrostatic shield in the high voltage transformer). Also used to sense whether a connection is made between A9J1/P1 and A21P3/J3 via cable assy 00-879447-XX.
KVP_SEN_POS	From kVp sense voltage divider in tank, A9P2/J2 to Backplane A1P3/J3. Positive going sense line of pair.
KVP_SEN_NEG	From kVp sense voltage divider in tank, A9P2/J2 to Backplane A1P3/J3. Negative going sense line of pair.
LO_MA_SEN_POS	From low mA sense resistors in tank, A9P2/J2 to Backplane A1P3/J3. Positive going sense line of pair.
LO_MA_SEN_NEG	From low mA sense resistors in tank, A9P2/J2 to Backplane A1P3/J3. Negative going sense line of pair.
HI_MA_SEN_POS	From high mA sense resistors in tank, A9P2/J2 to Backplane A1P3/J3. Positive going sense line of pair.
HI_MA_SEN_NEG	From high mA sense resistors in tank, A9P2/J2 to Backplane A1P3/J3. Negative going sense line of pair.
CBL_SHLD	Shields of the above three twisted pairs. Connected to tank chassis and to chassis ground at Backplane via cable asm 00-879454-XX.

Automatic Brightness Stabilization

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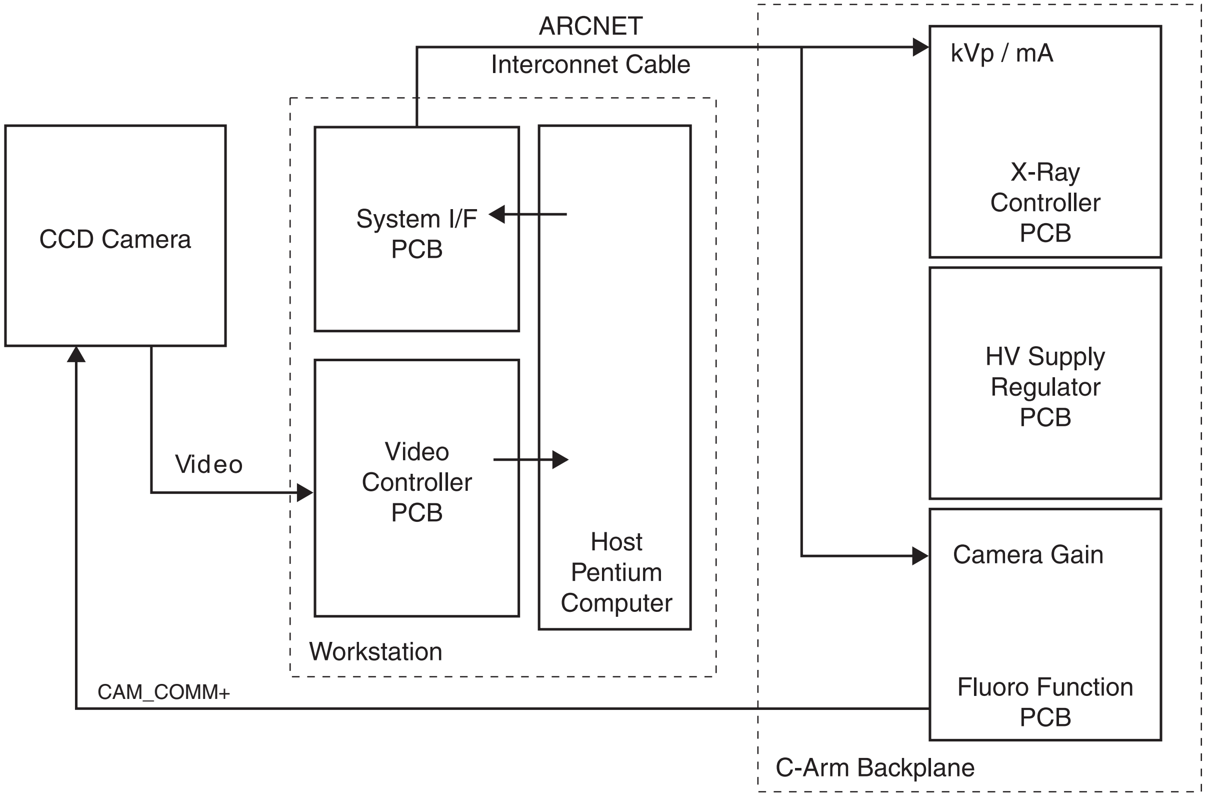
Circuit/Mechanical Descriptions

The Auto Brightness Stabilization circuitry adjusts the x-ray exposure parameters and camera gain to optimize the image while managing exposure rates to the subject. The control signals are applied to the CCD camera and generator kVP and mA.

The AUTO key on the Workstation keyboard turns the function on. The Control Panel Processor PCB sends the command for Automatic Brightness Stabilization to the Fluoro Functions PCB via the serial port. It is then relayed over the ARCNET to the Generator software on the X-ray Controller PCB. At this time, the Generator software enables the feature.

Video from the CCD Camera is also input to the Video Controller PCB in the Workstation. The Host Pentium computer looks at a particular section of the image, called the ABS Sample Window, to calculate the light level of the image. This value is then relayed to the generator software where the new kVP and mA, plus camera gain changes are calculated based on this light level. The kVp and mA changes are then set by the generator software. The Camera Gain changes are sent to the Fluoro Functions PCB via ARCNET.

The camera gain changes are sent to the CCD Camera via the CAM_COMM± lines. This process continues until the optimum image brightness is reached.


ARCNET
Interconnet Cable
CCD Camera
System I/F
PCB
Video
Controller
PCB
Host
Pentium
Computer
Workstation
Video
CAM_COMM+
kVp / mA
X-Ray
Controller
PCB
HV Supply
Regulator
PCB
Camera Gain
Fluoro Function
PCB
C-Arm Backplane

ABS Path

Functional Tests

Perform the following tests to verify that the system is operating satisfactorily.

(Refer to the *9800 C-Arm Sub-system* chapter of this manual for Functional Tests.)

1. System Boot
2. Make a fluoroscopic exposure.

WARNING: *The following procedure generates live x-rays. Take appropriate precautions against undue exposure.*

Take several Fluoro exposures using various filters in each. Note the change in brightness and contrast in the left monitor and determine if these images are automatically adjusted for the best brightness and contrast in each exposure.

Fault Isolation

WARNING: The following procedures generate live x-rays. Take appropriate precautions against undue exposure.

Failure	**Possible Cause**	**Remedy**
Black image – Technique servos to maximum (120 kVp).	Loss of video to Image Processor. (Camera, Intensifier, Video Cables, Video Control PCB).	Replace failed component or assembly.
	Possible loss of X-ray output (Generator Failure).	Troubleshoot and repair X-ray generator.
White Image – Technique servos to minimum (40 kVp).	Loss of video to Image Processor in such a way that video amplitude is constantly high. (Camera, Video Control PCB).	Replace failed component or assembly.
	Possible loss of X-ray control. (excessive output, not controllable).	Troubleshoot and repair X-ray generator.
Light or Dark Image with working ABS. (Technique adjusts and stabilizes as subject thickness is varied).	Calibration of TV Monitors may be incorrect.	Perform TV monitor calibration (see *Calibration* chapter in this manual).
	Possible failure in Video Controller PCB, reporting incorrect video amplitude to Image Processor.	Replace Video Controller PCB.
Low Contrast Images	Imaging technique. When imaging heavy anatomy, use collimation to avoid very bright non-attenuated areas, or reposition.	Applications training.

Failure	Possible Cause	Remedy
	Imaging Parameters may be corrupt.	Check Imaging Defaults (histo min & max) and check TV monitor calibration.
Kvp values too high or too low in “copper filter tracking test”	Incorrect CCD camera lens iris stop calibration.	Perform Lens Iris Stop calibration (see *Calibration* chapter in this manual).

Adjustments

None

Miscellaneous

Check Test points TP25 and TP26 on the Fluoro Functions PCB for camera gain adjustment data to the CCD Camera. Check TP11 on this PCB for a 1.6Mhz clock signal into U48.

Check Interconnect plug P1-J1, pins 7 and 8 for ARCNET traffic after inserting an additional filter and while taking a Fluoro exposure.

Check Interconnect Cable J1, pins 1, 2 and 13 (Video Hi, Video Lo, Shield) to see if the camera is sending video to the Workstation Video Controller PCB (PCB Connector P6, Pins 3, 4 and 8).

Collimator

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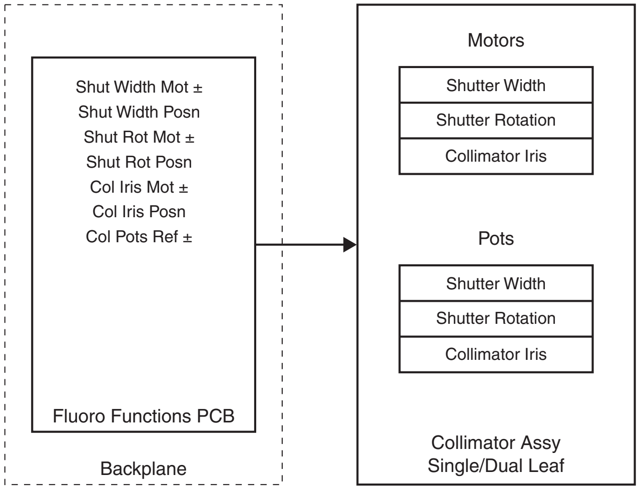
Circuit/Mechanical Descriptions

The collimator is an electrically actuated mechanism that restricts the x-ray beam to allow the exposure area to only be the size and shape desired by the operator. The unit has a lead iris and shutters and is mounted directly over the x-ray tube beam aperture. Software controls the motorized movements to shape the beam after it passes through the fixed primary collimator and exits the x-ray tube.

The collimator is controlled by software through the Fluoro Functions PCB. The Shutter Width, Rotation and Iris motors set the size and shape of the x-ray beam under control of the operator. The associated pots confirm the movement and position of the collimator parts back to the software.


Shut Width Mot ±
Shut Width Posn
Shut Rot Mot ±
Shut Rot Posn
Col Iris Mot ±
Col Iris Posn
Col Pots Ref ±
Fluoro Functions PCB
Backplane
Motors
Shutter Width
Shutter Rotation
Collimator Iris
Pots
Shutter Width
Shutter Rotation
Collimator Iris
Collimator Assy
Single/Dual Leaf

Colimation

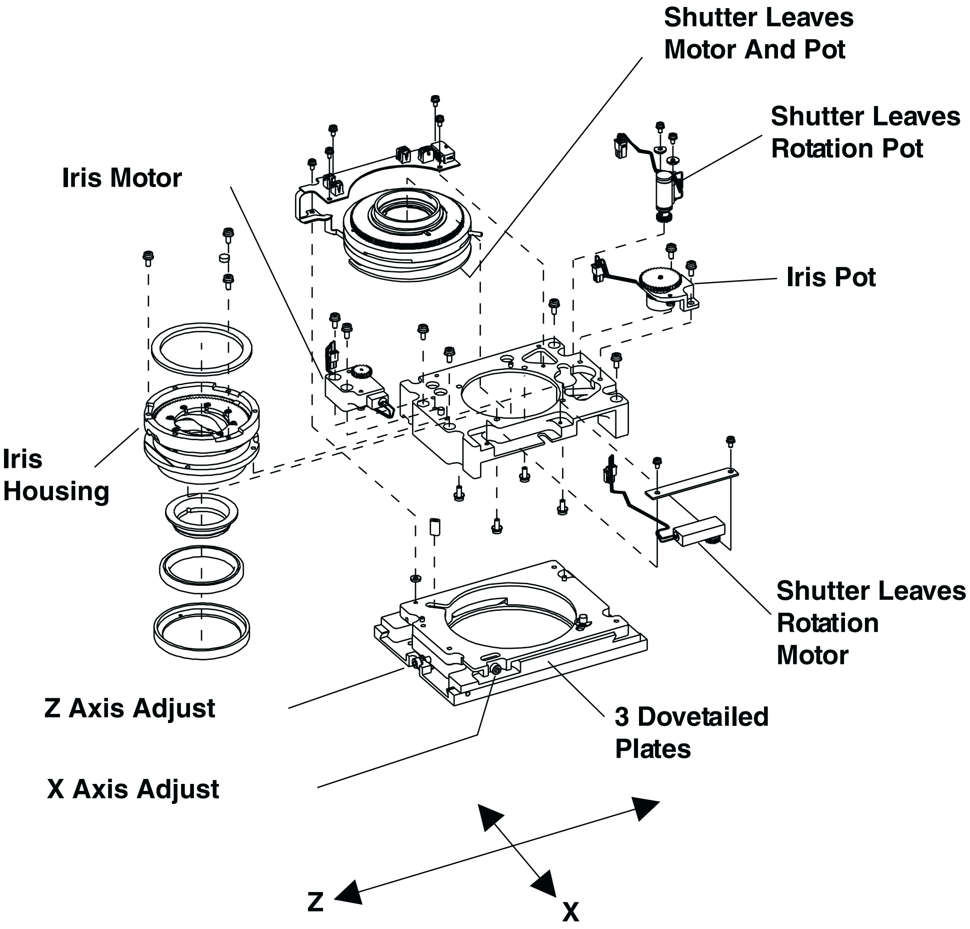
Functional Tests

The testing for correct collimation is part of the test procedures in the *C-Arm Subsystem* chapter of this manual. If the correct response to the collimation controls does not occur, you will receive error messages. If no error messages occur, yet the correct response fails to occur, follow the fault isolation procedures of the following section. For instructions on each error message, refer to the *Diagnostics* chapter in this manual.

Fault Isolation

Failure	**Possible Cause**	**Remedy**
Error messages about the collimator.		see the *Diagnostics* chapter in this manual.
Collimator hesitates, stops or lugs down movement motors in travel from stop to stop.	Collimator mechanism faulty	Apply proper lubrication and retest. Replace Collimator
Collimator “hunts” for the position.	Faulty Fluoro Function PCB	Check Fluoro Function PCB +5 volt output to Collimator motors Check Collimator position pots

Adjustments

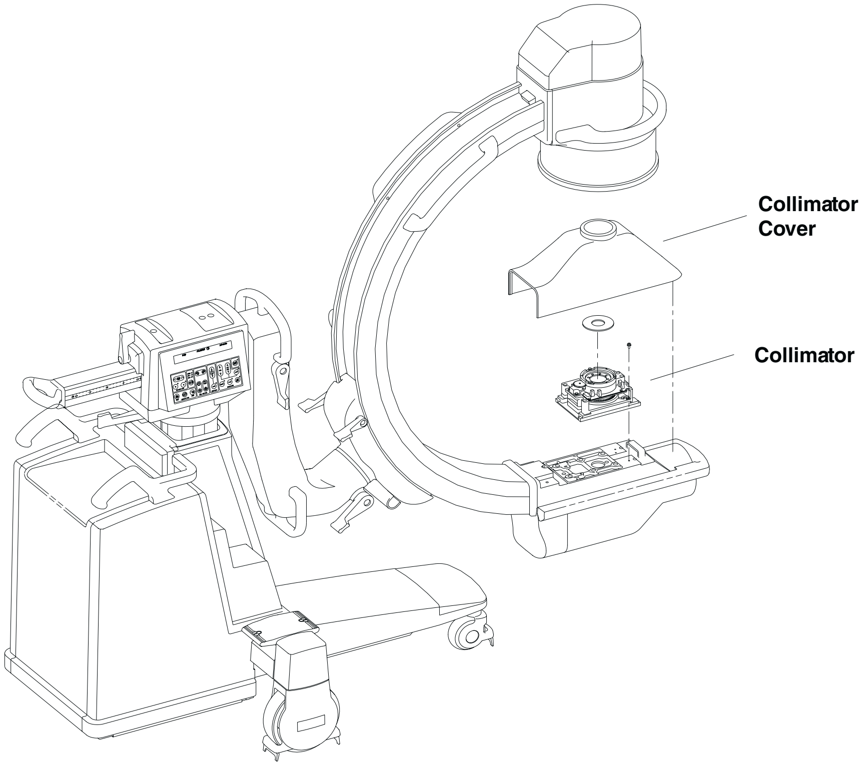

Shutter Leaves Motor And Pot
Shutter Leaves Rotation Pot
Iris Motor
Iris Pot
Iris Housing
Shutter Leaves Rotation Motor
Z Axis Adjust
3 Dovetailed Plates
X Axis Adjust
Z
X

Collimator Components

Three dovetailed mechanical plates accomplish adjustment of the collimator to the image chain. The plates are adjusted in two planes (X-axis and Z-axis) as shown in the above illustration to align the unit with the image chain.

Refer to the *Calibration* chapter of this manual for collimator calibration instructions.

Miscellaneous



Collimator Mounting

Image Control

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  CCD Camera....8

Circuit/Mechanical Descriptions

CCD Camera

The CCD Camera used with the system has a macro-focusing lens and video circuits that pick up images from the output face of the image intensifier tube. The camera sends those images to the Video Controller PCB in the Workstation for processing and storage, along with display on the workstation monitors and possible storage on videotape.

In operation, switch closures on the C-Arm control panel are sent to the Control Panel processor and then routed via RS232 communication to the Fluoro Function PCB. The Fluoro Function PCB microprocessor directs the camera to respond to the key operation; camera Iris control and camera rotation. The camera reports its status back to the PCB and the system by the readings from various positioning pots.

The Fluoro Functions PCB provides control to the CCD Camera motors and also to the Collimator motors (refer to the *Collimator* chapter of this manual for more details). Control of the camera gain and mode is accomplished with a manchester (digital) RS-422 signal. In addition, the PCB also supplies control voltages to the Image Intensifier (refer to the *Image Intensifier* section of this chapter for more details) to control field size and transfers data and other signals between the workstation and the Control Panel Processor PCB.

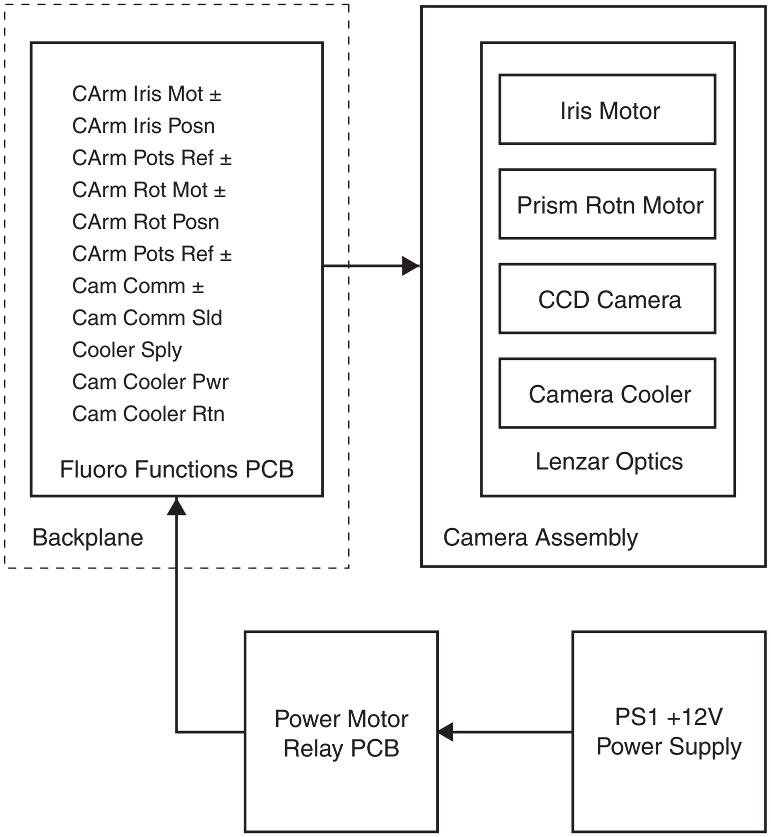
The manchester encoded data sent from the Fluoro Functions PCB to the camera is used to control camera gain, integration of multiple frames by the camera and camera mode (50/60 hZ).

Camera gain is used in the ABS control loop to achieve the desired brightness with the lowest technique. It is an output from the ***.abs*** tables stored on the C-arm.

The integration bit is used during pulsed shots at 4 pulses per second and less where the pulse length is greater than the frame time. The camera must be told to integrate across multiple frames to acquire all the photons.

The mode is used to command either 50 or 60 hZ operation since the 9800 camera is capable of operating at either frame rate (40 ms frame time at 25 frames per second or 33.3 ms frame time at 30 frames per second).

If the manchester data is not being sent and received properly you should expect to see faulty ABS behavior and dark images in pulsed fluoro shots at 4 pulses per second and less.


CArm Iris Mot ±
CArm Iris Posn
CArm Pots Ref ±
CArm Rot Mot ±
CArm Rot Posn
CArm Pots Ref ±
Cam Comm ±
Cam Comm Sld
Cooler Sply
Cam Cooler Pwr
Cam Cooler Rtn
Fluoro Functions PCB
Backplane
Iris Motor
Prism Rotn Motor
CCD Camera
Camera Cooler
Lenzar Optics
Camera Assembly
Power Motor Relay PCB
PS1 +12V Power Supply

CCD Camera Control and Power

Image Intensifier Tube and Power Supply

The Image Intensifier (II) Tube is a cathode ray tube mounted on the end of the C-weldment opposite the X-ray Tube. The II Tube and Power Supply are contained beneath the II cover. The CCD Camera is mounted on the bottom of the II assembly.

The II tube receives the x-rays and produces a bright reduced-size image on its bottom phosphor glass plate. The camera sends a video picture to the Workstation monitors of the x-ray image projected on bottom II output plate.

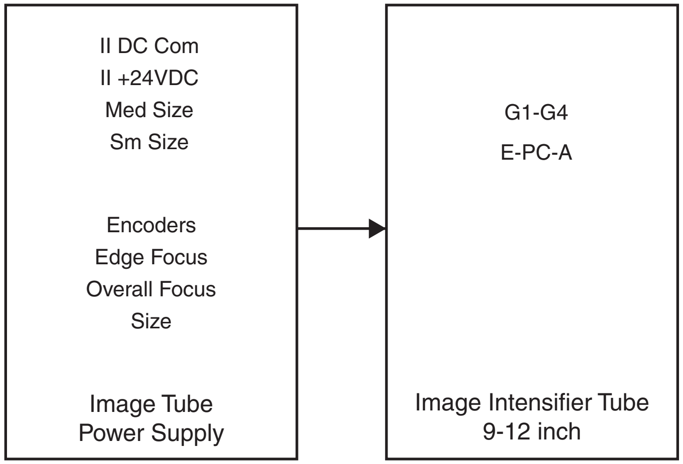


Image Intensifier Tube and Power Supply

A power supply attached to the II housing produces the voltages needed for the internal electrostatic focusing and deflection grids of the II. The II is available in 9- or 12-inch sizes. The normal operating mode is supported by both II sizes, plus two levels of magnification.

The II Power Supply mounted on the II tube assembly powers both the 9- and 12-inch II versions. The power supply operates on +24 volts from System Power Supply PS2. The Fluoro Functions PCB controls the II power supply. This PCB varies the grid voltages to the tube in accordance to the mode in which the II is to operate. The II Power Supply also generates the II tube anode voltage, with a maximum of 29.5 kV.

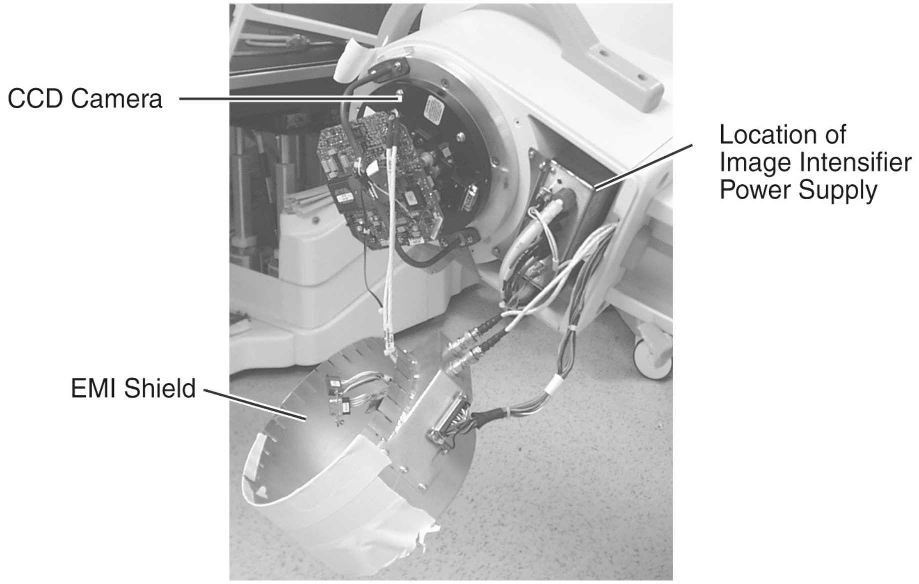

CCD Camera
Location of
Image Intensifier
Power Supply
EMI Shield

Image Intensifier Power Supply

Functional Tests

CCD Camera

To verify correct operation of the CCD Camera, perform Boot Test and Fluoro Mode performance check in the C-Arm Subsystem chapter of this manual. Verify that the image quality is acceptable.

Image Intensifier and Power Supply

Using copper filters, successively add filters onto the II surface. Observe the image and verify that the system compensates for each added filter, boosting the brightness and contrast of the monitor image as the filters are added.

WARNING: *The following procedure generates X-Rays. Take appropriate precautions when performing this procedure.*

The Fluoro Functions PCB controls the following camera motor functions:

- Camera Iris (Open/Close)
- Camera Optics (Rotation)
- Collimator Leaves (Open/Close)
- Collimator Leaves (Rotation)
- Collimator Iris (Open/Close)

A failure on the Fluoro Functions PCB may result in an array of symptoms. Some failures may result in an error message being displayed on the Mobile C-Arm’s Control Panel.

WARNING: *Do not measure the output of the power supply to the Image Intensifier tube. A lethal anode voltage exists on this connector.*

Check the output of Power Supply PS2 and make sure the output voltage is +24VDC.

Using a voltmeter, measure the +24 volt supply to the II power supply at J7, between pins 15 - 8 and at the output of Power Supply PS2. If problems are noted in changing from small to medium fields, check the MD_FIELD signal on pin 14 of J7. The SM_FIELD signal is on pin 6 of J7.

Fault Isolation

CCD Camera

Failure	Possible Cause	Remedy
In Fluoro Mode: Irregularities when Field Size changes	Control Panel Processor PCB Fluoro Functions PCB. See Error Messages	Check Control Panel PCB Check Fluoro Functions PCB
Collimator movements are jerky or sticky	Collimator lubrication	Lubricate the Collimator and retest for smooth movement (see *Collimator* chapter)
CCD Camera rotation binds or exhibits jerky motion	Fluoro Functions PCB	Check Fluoro Functions PCB
Video abnormalities, artifacts, video drop-outs	CCD Camera	Check CCD Camera, Video and image chain Check Fluoro Functions PCB
ARCNET Communications failure Symptoms: Control Panel button pushes may not cause the intended change on the workstation.	Fluoro Functions PCB See Error Messages	Check Fluoro Functions PCB
Camera Cooler Failure Symptoms: Bright pixels may be present in image due to offset correction failure.	Fluoro Functions PCB See Error Messages	Check Fluoro Functions PCB
Camera control Failure (Manchester Encoder /Decoder) Symptoms: Pulse rates less than 4 pps will show dark images due to failure of integrating data over multiple frame times. Auto Brightness Stabilization not correct.	Fluoro Functions PCB See Error Messages	Check Fluoro Functions PCB

Image Intensifier and Power Supply

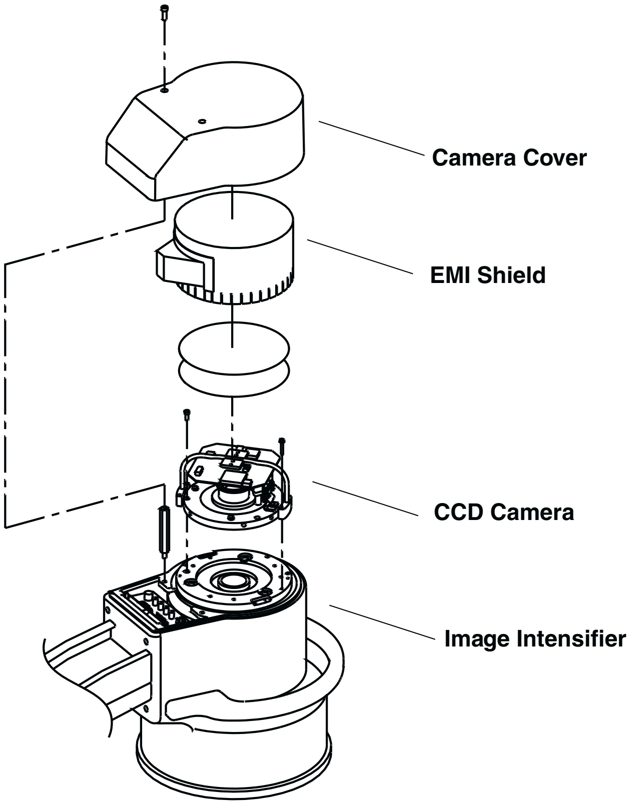
Failure	Possible Cause	Remedy
No Image on Monitor.	Bad II or Power Supply, Bad Camera, Bad Monitor.	Does kV track to 120? If yes check CCD Camera and output of II.
Image out of Focus	II Power Supply, II tube problems, CCD Camera	Check if II and Camera can be focused. Check all MAG sizes

Adjustments

(see *Calibration* section)

Miscellaneous

CCD Camera


Camera Cover
EMI Shield
CCD Camera
Image Intensifier

CCD Camera Parts Locations

The following table lists the test points available on the Fluoro Functions PCB, including those that affect the CCD Camera:

Test Point	Description	Test Point	Description
1	5V_MOTOR_PWR	23	-12VDC
2	CPU DC	24	VR1 OUT
3	CPU RESET	25	CAM_COMM+
4	20 MHz CLOCK (ARCNET)	26	CAM_COMM-
5	ARC_INT (ARCNET)	27	+12 vdc
6	ARCNET_LO (ARCNET)	28	POS_15V (Filtered)
7	ARCNET_HI (ARCNET)	29	Y1 ENABLE
8	CPU_RD-WR	30	VCC +5VDC
9	Pin 68-Pin 33 Loop (ARCNET)	31	GND
10	16 MHz CLOCK	32	INT_FS
11	16 MHz CLOCK (U48)	33	INT_ARC
12	CPU AS	34	CAM_ROT (Position Filters)
13	LIM_REF (Motor Limit)	35	CAM_IRIS (Position Filters)
14	FRAME_SYNC_LO (ARCNET)	36	CAM_ROT (Position Filters)
15	INT_FSYNC (ARCNET)	37	COL_WIDTH (Position Filters)
16	FRAME_SYNC_HI (ARCNET)	38	COL_IRIS (Position Filters)
17	CPU PBRST	39	SPARE_CH (Position Filters)
18	AGND	40	FLD_SIZE (Position Filters)
19	WD_STRB	41	COOLER_PWR_MON
20	TRI-ST (ARCNET Chip Select)	42	GND
21	Not Used	43	GND
22	NET_15V (Filtered)	44	GND

Cooling

Circuit/Mechanical Descriptions **2**
X-ray Tube Cooling 2
CCD Camera Thermoelectric Cooling 4
Fault Isolation **5**
Functional Tests **6**
Adjustment **6**
Miscellaneous **6**

Circuit/Mechanical Descriptions

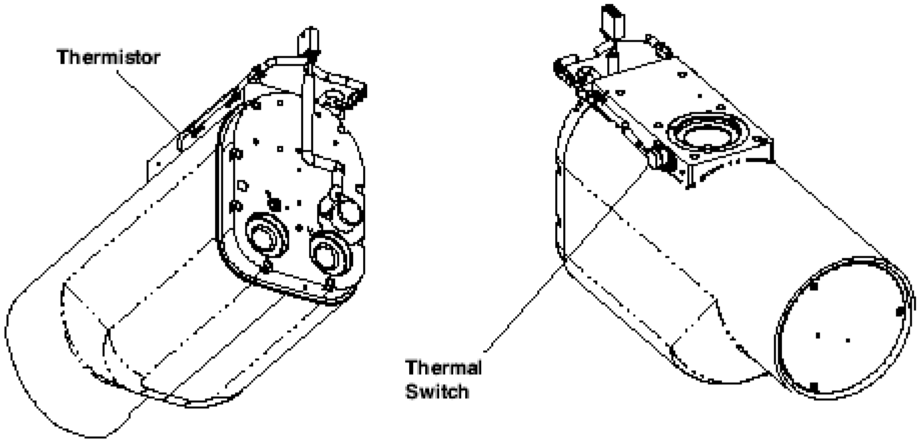
There are two separate and unrelated cooling functions: for the X-ray tube, and for the CCD camera.

X-ray Tube Cooling

The X-ray Tube used on the 9800 C-Arm has a rotating anode and two filaments. In operation, the filaments and rotating anode generate heat as X-Rays are produced. The Anode heat capacity is 300,000 Heat Units (H.U.) and heat dissipation is 60,000 H.U./minute. X-ray Tube Housing storage capacity is 1,600,000 H.U. and heat dissipation is 15,000 H.U./minute. If the heat generated exceeds the heat dissipation because of constant use, some means of monitoring and removing the excess heat must be employed. The X-Ray tube is enclosed in a case that is filled with oil. The oil provides rapid removal and dissipation of the tube-generated heat.

A thermistor is used to monitor X-ray Tube temperature. A Thermal Switch is used as additional protection in case the thermistor or associated circuitry fails. Both components are shown in the following illustration.

The thermal switch protects the tube from excessive heat and pressure. The contacts are normally closed, but they open if the temperature exceeds 181° ± 5° F. The switch is located on the side of the X-ray Tube.


Thermistor
Thermal Switch

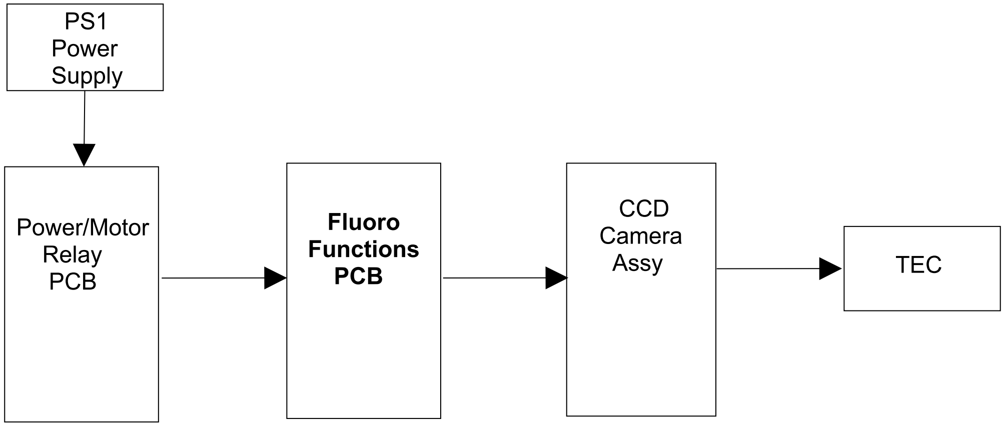
X-Ray Tube Thermistor and Thermal Switch

CCD Camera Thermoelectric Cooling

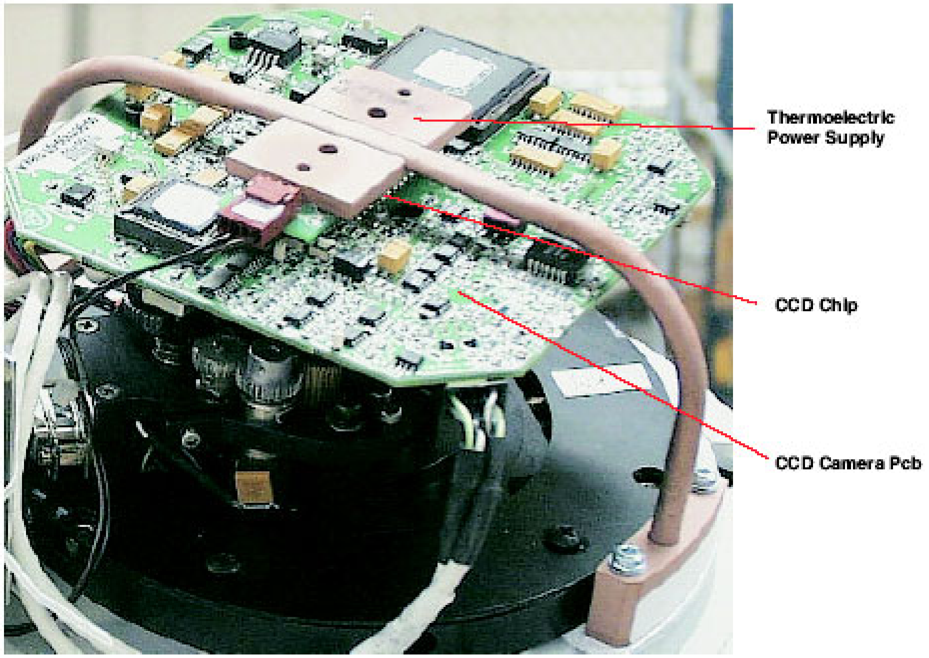
A second source of generated heat is the CCD Camera. The CCD chip in the camera generates considerable heat as it helps create video from the visible light images on the Image Intensifier output phosphor. A themoelectric cooler (TEC) heat sinked to the back of the CCD chip helps keep the chip cool enough to perform in its linear region and avoid damage. The TEC is actually a solid-state heat pump that draws heat from the CCD and transfers it to a heat sink. If the CCD Camera is not cooled, the “dark” current will increase. That would result in greater fixed paattern defects. However, white dots may appear due to failure of the offset correction hardware on the Video Control PCB, or software.

The TEC requires +5 Volts at about 2.5 watts to adequately cool the CCD. The Power/Motor Relay PCB receives +12 Volts from Power Supply PS1 through a voltage-dropping array to produce the +5 Volts.

The +5 Volts is sent from the Fluoro Functions PCB to the TEC. A Field Effect Transistor turns power to the TEC on and off under software control. TEC is mostly off after system boot-up. The on/off algorithm under softare control increases the on time (duty cycle) so that more cooling takes place the longer the system is booted.



CCD Camera Thermoelectric Cooling


Thermoelectric Power Supply
CCD Chip
CCD Camera Pcb

CCD Camera and Thermoelectric Cooler

Fault Isolation

CCD Camera cooling failure can be indicated when the following occurs:

- HOUSING OVERHEATED error message (see *Diagnostics* chapter).
- The system shuts down without displaying an error message.

If either of these has occurred, perform the cooling system functional test following.

Functional Tests

To test the CCD Camera cooling function, proceed as follows:

1. Verify power at the TEC.
   - A. If no power available, go to Step 2.
   - B. If power present, replace cooler assembly.
2. Verify +5VDC at output of Fluoro Functions PCB
   - A. If power is present, verify good connections between Fluoro Functions PCB and TEC.
   - B. Check power at input to Fluoro Function PCB. If power present, replace the Fluoro Functions PCB.
3. Verify presence of +12VDC at output of Power/Motor Relay PCB.
   - A. If no voltage present, verify voltage at the input of PS1. If voltage present, replace PS1.
   - B. If voltage present, verify cables and connectors between Power/Motor Relay PCB and Fluoro Function PCB.

Adjustment

None

Miscellaneous

None

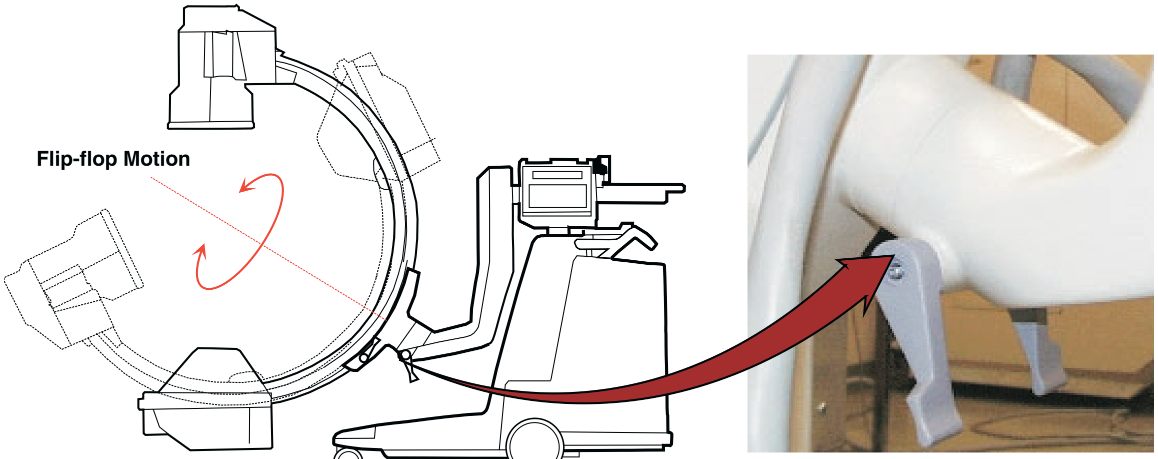
Flip Flop Motion

Circuit/Mechanical Descriptions........2
Functional Tests........3
Fault Isolation........3
Adjustment........3
Miscellaneous........4

Circuit/Mechanical Descriptions

The C can pivot on its cradle axis ±180 degrees. A Flip-Flop brake secures the C in whatever position you choose. There is a brake handle on either side of the Flip-Flop assembly. To secure the C and prevent further rotation on the cradle axis, position either brake handle toward the “lock” icon.

CAUTION: *When you release the Flip-Flop brake handle, place your other hand on the C so that you have full control of its movement.*



Flip-flop Brake Handles

Flip-Flop Movement and Brake Handle

Functional Tests

1. Release the Flip Flop brake and verify that the C can rotate freely in both directions.
2. Set the Flip Flop brake and verify that it prevents the C from rotating on its cradle in either direction.

Fault Isolation

Problem	Possible Cause	Solution
C-Arm does not rotate freely when Flip Flop brake is released.	Flip Flop brake shoe is loose and stuck in wrong position.	Disassemble brake in accordance with instructions in Replacement chapter and check brake shoe position. Secure brake shoe mounting hardware if necessary.
Flip Flop brake does not prevent Flip Flop movement of C-Arm and adjusting the brake doesn't help	Flip Flop brake shoe is loose or worn out	Disassemble brake in accordance with instructions in Replacement chapter and check brake shoe for wear. Replace brake shoe if necessary.
Flip Flop brake does not prevent Flip Flop movement of C-Arm.	Brake is out of adjustment	Adjust brake in accordance with the following paragraph.

Adjustment

The Flip Flop Brake on a Standard C-Arm and Super C-Arm are substantially the same. The Super C has an addition adjustment for setting drag to prevent C-free falling when the flip flop brake is released. Both the Standard C-arm and Super-C Flip Flop Brakes are shown in the *Flip Flop* section of the *Replacement* chapter.

If there isn’t sufficient tension on the brake shoe before the Mechanical Brake Stop contacts the brake handle, follow these steps to adjust the brake handle position.

1. Remove the brake handle screw from the Brake Handle that has the Mechanical Brake stop.
2. Pull the Brake Handle off far enough that it clears the Mechanical Brake stop.
3. Tighten the brake by turning the brake handle.

4. Remove the Brake Handle and reposition it on the shaft so that the Mechanical Brake stop fits in the Brake Handle’s slot.
5. Secure the Brake Handle with the screw.
6. Adjust the position of the second brake handle so that both handles are uniform.
7. If the brake cannot be adjusted, replace the Flip Flop Brake Shoe.
8. The Flip Flop Brake Shoe can be replaced by separating the Flip Flop from the L Arm.

Miscellaneous

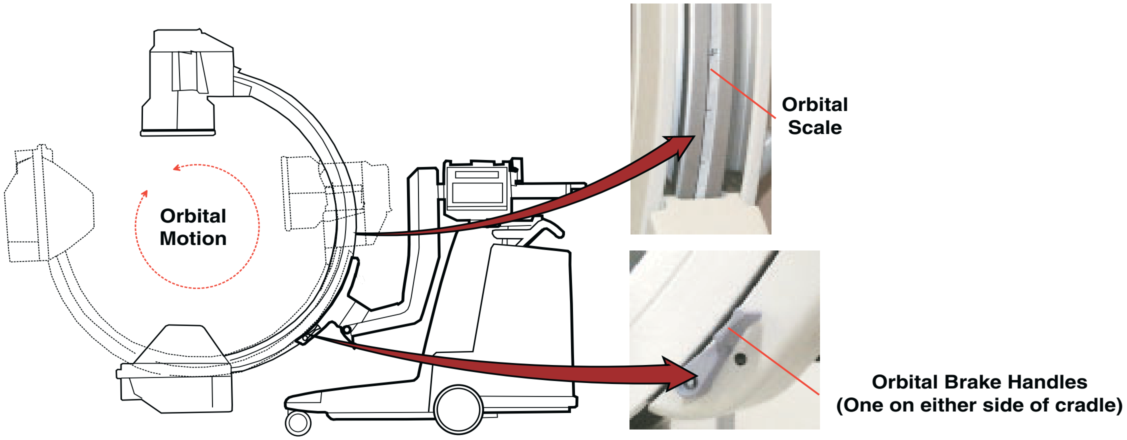
Not applicable.

Orbital Motion

Circuit/Mechanical Descriptions........2
Functional Tests........3
Fault Isolation........4
Adjustment 4
Miscellaneous........4

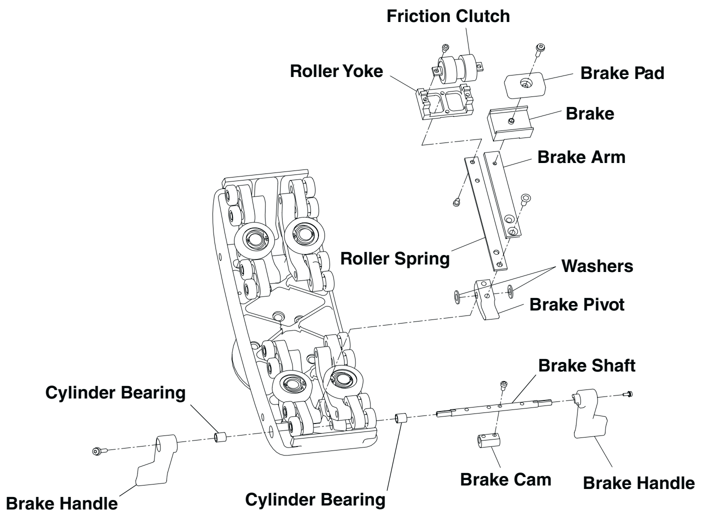
Circuit/Mechanical Descriptions

The C-Arm can rotate in its cradle through an arc of 115 degrees. The back of the C weldment has a scale that aids in positioning the C as it rotates. Once the position of the C is satisfactory, set either brake handle to the lock icon on the cradle to keep the C from moving.



Orbital Movement and Brake

The following illustration is an exploded view of the C-Arm's Orbital Brake. Rotating either brake handle moves the Brake Cam against the Brake Pivot, which in turn presses the Brake Arm toward the C-Arm. The Brake Pad attached to the Brake Arm presses against the back of the C-Arm, preventing orbital movement of the C.


Friction Clutch
Roller Yoke
Brake Pad
Brake
Brake Arm
Roller Spring
Washers
Brake Pivot
Brake Shaft
Cylinder Bearing
Brake Cam
Brake Handle
Brake Handle
Cylinder Bearing

Orbital Brake Assembly

Functional Tests

***CAUTION**:* *When you release the orbital movement brake, place your other hand on the C so that you have full control of the its movement.*

Release the orbital brake. Verify that the C orbits smoothly in its cradle through an arc of 115 degrees. Verify that the entire orbital scale on the back of the C weldment is readable and in good condition. Set either brake handle to the “lock” icon on the cradle to keep the C from moving. Verify that the C does not move. Release the brake and set the other brake handle to the "lock" icon. Verify that the C locks firmly in position.

Fault Isolation

Inspect the Orbital Brake Assembly if the orbital brake either fails to engage or release as it should. Replace any worn or broken parts. Refer to the Replacement chapter for disassembly instructions.

Adjustment

No initial or periodic adjustment of C-Arm orbital movement is required.

Miscellaneous

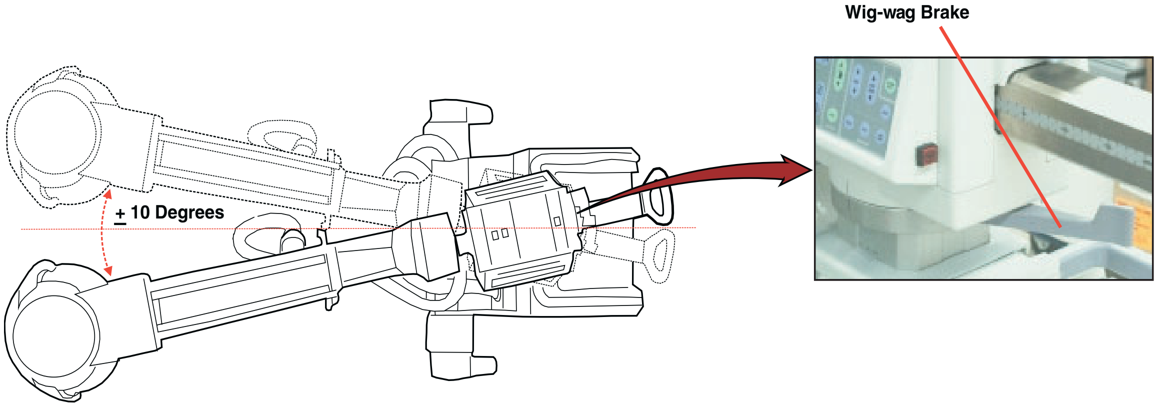
Not applicable.

Wig Wag Motion

Circuit/Mechanical Descriptions **2**
Functional Tests **4**
Fault Isolation **4**
Adjustment **5**
Miscellaneous **6**

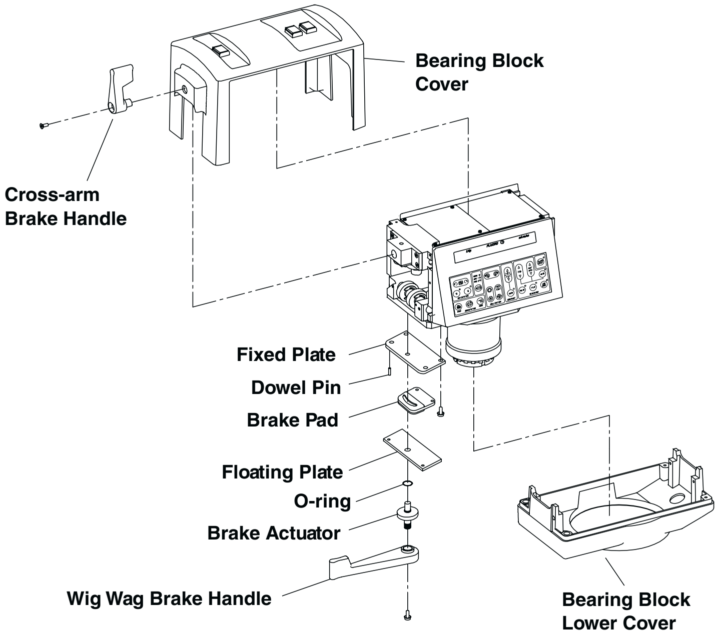
Circuit/Mechanical Descriptions

The entire C-Arm can pivot laterally (wig wag) ±10 degrees as shown in the following illustration. A brake assembly allows you to pivot the C-Arm to a convenient position and then lock it in place.



Wig Wag Motion and Brake

The following illustration shows the internal parts associated with the Wig Wag feature. The brake operates by compressing the Brake Pad between the floating plate and fixed plate shown below.


Bearing Block
Cover
Cross-arm
Brake Handle
Fixed Plate
Dowel Pin
Brake Pad
Floating Plate
O-ring
Brake Actuator
Wig Wag Brake Handle
Bearing Block
Lower Cover

Wig Wag Motion and Brake Mechanics

Functional Tests

Loosen the Wig Wag brake and turn the Cross-Arm right or left 10 degrees on its Vertical Column mount. Make sure the Cross Arm turns freely with the brake released. Make sure you can tighten the Wig Wag brake to secure the Cross Arm in any normal lateral position.

CAUTION: *Position Cross Arm housing facing straight ahead and set Wig Wag brake before moving C-Arm. Equipment damage or personal injury may otherwise result.*

Fault Isolation

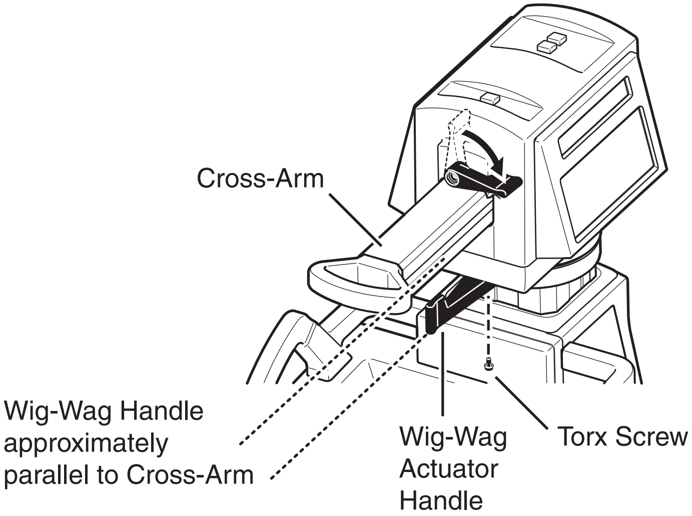
If the Wig Wag brake does not work, inspect the Wig Wag brake mechanism, and replace any worn or broken parts.

If the Wig Wag motion does not work, look for loose or dragging brake parts. Follow the instructions in the Replacement chapter of this manual.

Adjustment

The Wig-Wag pivot mechanism does not require initial or periodic mantenance. The Wig-Wag brake is also adjusted at the factory so that when the brake engages, the brake handle is approximately parallel to the cross-arm. However, after you replace the brake, adjust as needed:

1. Remove Torx screw that retains the brake handle.
2. Remove the handle.
3. Adjust the brake acuator screw adjuster in to make the brake engage earlier, or out to engage later.
4. Reinstall the handle onto the cross-arm in a position approximately parallel to the cross-arm with the brake engaged.


Cross-Arm
Wig-Wag Handle approximately parallel to Cross-Arm
Wig-Wag Actuator Handle
Torx Screw

Adjustment of the Wig-Wag Brake

Miscellaneous

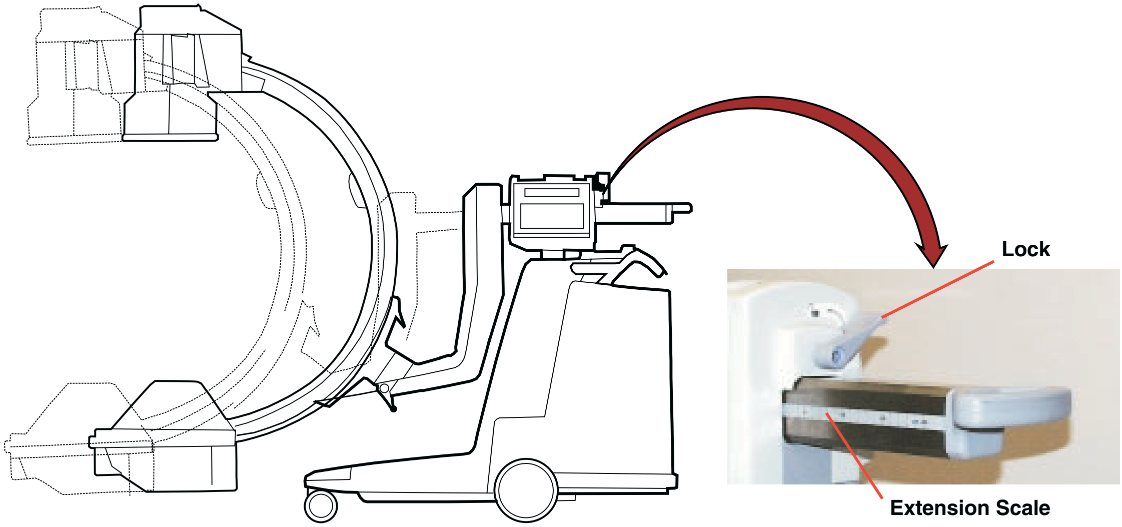
Not applicable.

Horizontal Cross Arm Motion

Circuit/Mechanical Descriptions........2
Functional Tests........4
Fault Isolation........4
Adjustment........4
Miscellaneous........4

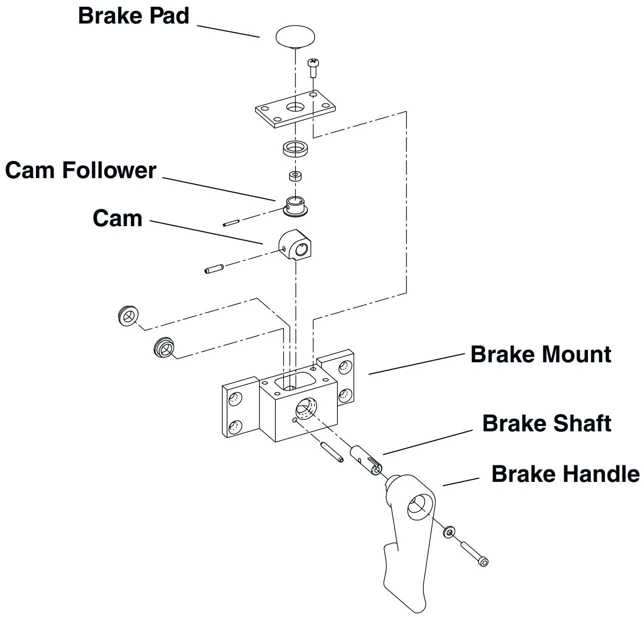
Circuit/Mechanical Descriptions

The Horizontal Cross Arm supports the C-Arm in front of the Generator. Roller bearings in the Cross Arm Bearing Block permit you to extend or withdraw the C-Arm to a suitable position. You can then use the Cross Arm brake to secure the C-Arm in position.



Horizontal Extension Handle and Brake

The following illustration shows the Cross Arm brake assembly. Setting the Cross Arm brake engages a brake pad that bears against the Cross Arm. This prevents the Cross Arm from moving.


Brake Pad
Cam Follower
Cam
Brake Mount
Brake Shaft
Brake Handle

Cross Arm Brake Assembly

Functional Tests

Unlock the Horizontal Cross Arm and extend it about eight inches forward from the normal transport position. (The Cross Arm has a calibrated extension scale that aids in precise positioning.) To extend the Cross Arm, move the brake to the UNLOCK position, push the Cross Arm into position, and set the brake handle to the LOCK position. Verify that the Cross Arm does not move after you lock it in place.

Note: The Cross Arm brake uses a cam with 90 degrees of travel. Attempting to push the handle past its 90-degree lock position will not apply the brake more securely, but may instead result in damage to the mechanism.

***CAUTION**: Make sure Cross Arm is fully retracted and brake is set before moving C-Arm. Equipment damage or personal injury may otherwise result.*

Fault Isolation

A malfunctioning Cross Arm Brake can prevent you from securing the Cross Arm, or it can prevent you from moving the Cross Arm at all. To confirm a Cross Arm brake failure, remove the Cross Arm bearing cover (refer to *Replacement* chapter, in this manual), and inspect the brake mechanism.

Adjustment

The Cross Arm brake requires no initial or periodic adjustment.

Miscellaneous

Not applicable

L-Arm Motion

Circuit/Mechanical Descriptions **2**
  - L-Arm Motion 2
  - L-Arm Servicing Hazards 4
  - L-Arm Brake 6

Functional Tests **8**
Fault Isolation **8**
Adjustment **8**
Miscellaneous **9**

Circuit/Mechanical Descriptions

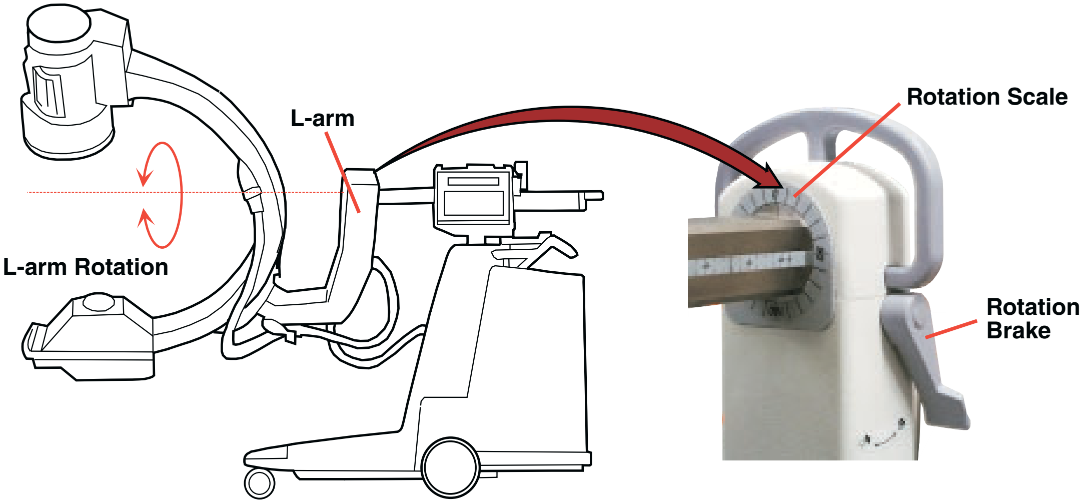
The following paragraphs describe normal L-Arm Motion, L-Arm Hazards, and how to check operation of the L-Arm Brake.

L-Arm Motion

Note: *There is no L-Arm on the Super C*

You can manually rotate the L-Arm on the end of the Cross Arm up to 180 degrees in either direction. Gas-shocked-dampened springs inside the L-Arm hold it in place when you remove your hand. A rotation indicator on the back of the L-Arm shows its current angular position. Set the L-Arm brake to secure the L-Arm in position.

CAUTION: *Watch carefully when you manually rotate the L-Arm. Even a low-speed collision can result in significant personal injury or equipment damage.*


L-arm
L-arm Rotation
Rotation Scale
Rotation
Brake

L-Arm Rotation and Brake

L-Arm Servicing Hazards

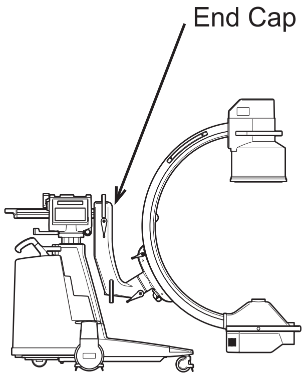
WARNING: Read the following information carefully before attempting to replace the Image Intensifier or X-ray tube, and before repairing or adjusting the L-Arm brake. Failure to observe these precautions could result in death, personal injury, or equipment damage.

Two powerful gas-shock-dampened springs balance L-Arm rotational movement in a Standard nine-inch or 12-inch system. These springs mount out of sight inside the L-Arm, and normally require no maintenance for the life of the system. They make it easy for you to manually position the L-Arm in any convenient position, and have the L-Arm remain stationary when you remove your hand.

WARNING: Before you remove the X-Ray Tube or the Image Intensifier, you must secure the L-Arm with a safety bolt to avoid inadvertent spinning of the L-Arm due to its the unbalanced condition. It is possible for the unbalanced L-Arm to rotate very quickly and very forcefully, causing personal injury and equipment damage.

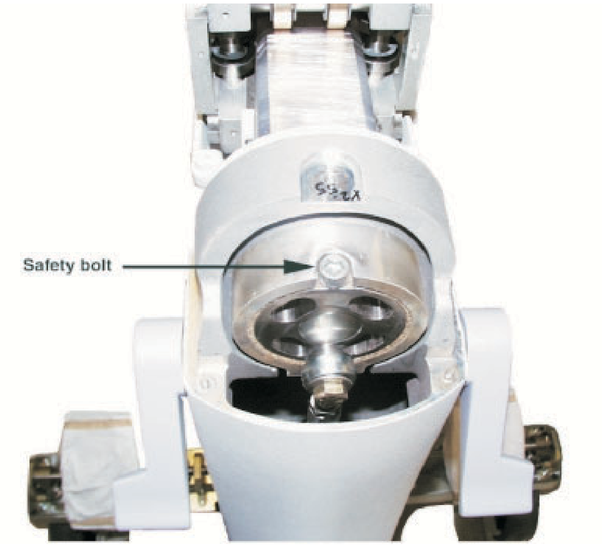
Follow these steps to secure the L-Arm before performing related maintenance:

1. Obtain the 3/8-16 x 3/4” UNC safety bolt.
2. Remove L-Arm end cap (see next picture). Set bolt and hole cover aside.



Safety Bolt Access

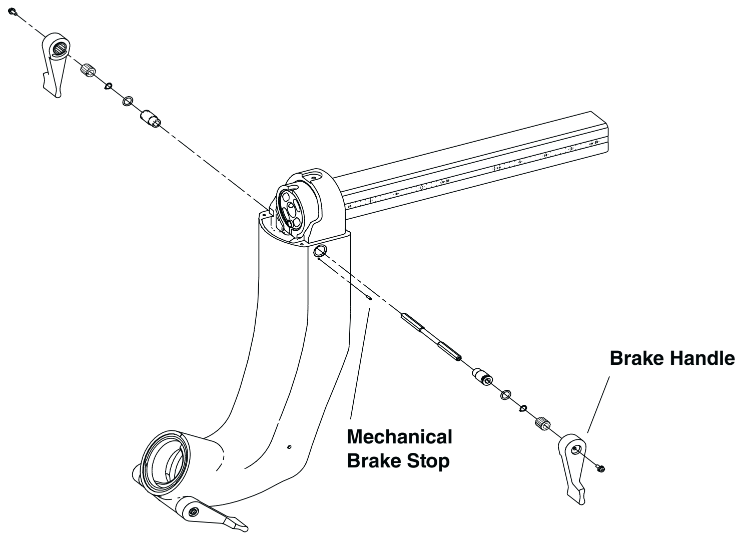
3. Position L-Arm in normal vertical position as shown in the picture above. Do not set L-Arm brake at this time.
4. Position C vertically and set Flip Flop brake.
5. Rotate L-Arm slightly until hole for safety bolt becomes visible. Install and secure safety bolt as shown in the following illustration. Secure the L-Arm brake.
6. Perform required maintenance, making sure to reinstall all removed items so that C is once again balanced.
7. Remove safety bolt.
8. Install L-Arm end cap and secure its mounting bolt. Be sure to install hole cover you removed in step 2.
9. Release L-Arm brake and check L-Arm for balanced and smooth rotation.



C-Arm Safety Bolt

L-Arm Brake

The following illustration is an exploded view of the L-Arm Brake assembly. If the L-Arm brake doesn't work correctly, check the adjustment of the Brake Handle first, and then look for a loose, damaged, or worn out Brake Pad.


Brake Handle
Mechanical
Brake Stop

L-Arm Brake Assembly

Functional Tests

1. Release L-Arm Brake and verify that L-Arm rotates smoothly in both directions.
2. Set L-Arm brake. Verify that L-Arm Brake locks the L-Arm firmly in position before brake handle contacts mechanical stop.

Fault Isolation

Problem	Possible Cause	Solution
L-Arm does not rotate freely	Brake shoe is loose and stuck in wrong position.	Disassemble brake in accordance with instructions in Replacement chapter and and check brake shoe position. Secure brake shoe mounting hardware if necessary.
L-Arm brake does not secure L-Arm and adjusting the brake doesn't help	Brake shoe is loose or worn out	Disassemble brake in accordance with instructions in Replacement chapter and check brake shoe for wear. Replace brake shoe if necessary.
L-Arm brake does not secure L-Arm.	Brake is out of adjustment	Adjust brake in accordance with the following paragraph.

Adjustment

If brake doesn't engage before mechanical brake stop contacts brake handle, adjust brake handle position as follows:

1. Remove brake handle screw from the brake handle that has the mechanical brake stop.
2. Pull the brake handle off far enough that it clears mechanical brake stop but can still be used to tighten the brake shoe.
3. Tighten the brake by turning the brake handle.
4. Remove the brake handle and reposition it on the shaft so that the mechanical brake stop fits in the brake handle’s slot.
5. Secure the brake handle with the screw.

6. Adjust the position of the second brake handle so that both handles have the same angular position.
7. Retest the brake.

If brake does not engage even after brake handle position adjustment, replace the L-Arm brake shoe. (Refer to Replacement chapter in this manual for details.)

Miscellaneous

Not applicable.

L-Arm Motion

Vertical Column Motion

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- Power/Signal Interface PCB 7
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Circuit/Mechanical Descriptions

The following paragraphs describe how the Vertical Column Lift, Vertical Column Power Supply PS3, Power/Motor Relay PCB, Power/Signal Interface PCB, and Vertical Column Lift Buttons work together to move the Vertical Column up and down.

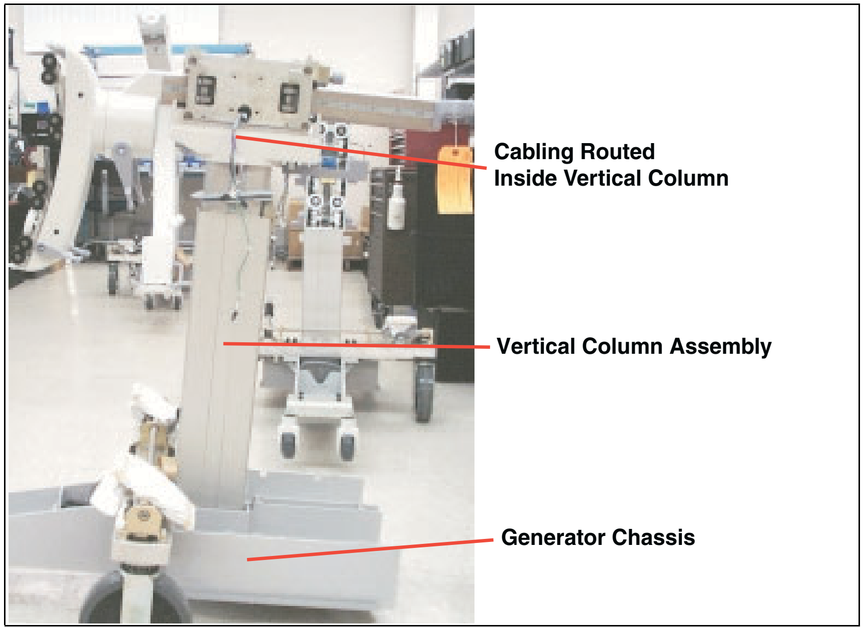
Vertical Column Lift

***CAUTION**:* *Be careful when you move the motorized Vertical Column. Even a low-speed collision can cause significant personal injury or equipment damage.*

The Vertical Column Lift raises and lowers the Cross Arm bearing assembly to position the C at a desired working height. The Lift can raise the Cross Arm bearing assembly up to 18 inches (46 cm) above its normal transport height. An internal, reversing 24-volt DC motor damped by a gas shock mechanism extends and retracts the Lift.

The Vertical Column Lift also serves as a conduit for cabling that runs between generator circuitry and the Control Panels. Although you can replace broken connectors in the field, broken cabling inside the Vertical Column Lift or a malfunctioning Lift mechanism usually means the entire Vertical Column Lift assembly must be replaced. The Vertical Column Lift is not field repairable.

The following illustration shows a partially constructed C-Arm on the manufacturing floor. Note that the Vertical Column Lift assembly complete with cabling has been installed on the generator chassis.


Cabling Routed
Inside Vertical Column
Vertical Column Assembly
Generator Chassis

Vertical Column Lift with Cabling

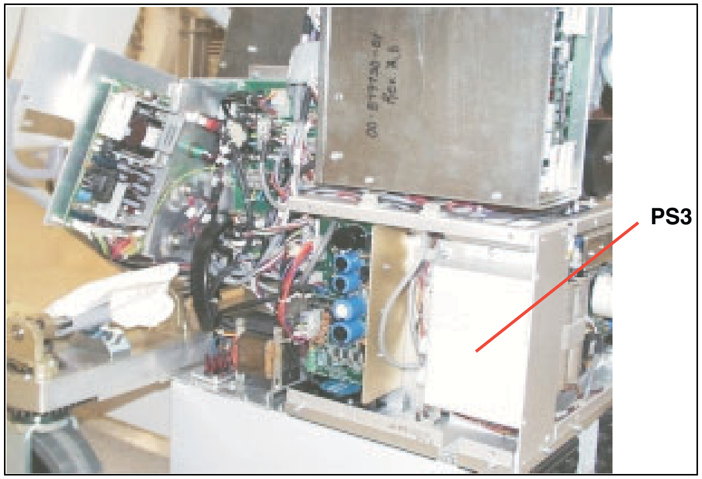
Vertical Column Power Supply PS3

The Vertical Column Power Supply produces 24 VDC at 6 Amps, which powers the DC motor that drives the Vertical Column up and down. PS3 also produces 36 VDC, which it uses to interface with the Vertical Column Lift buttons. PS3 mounts on the left-hand side of the generator under the Left Side Cover as shown in the following illustration.

PS3 has three connectors:

- The input power connector, which accepts 115 VAC from the Power/Motor Relay PCB.
- The output power connector provides 24 VDC of the proper polarity to drive the Vertical Column Lift up or down.

- The control connector, which accepts switch closure signals from the Vertical Column Lift Buttons. These buttons apply 36 VDC to the LIFT_UP_SW or the LIFT_DN_SW selector line on PS3. The Vertical Column Lift moves up or down, depending on which selector line receives the 36 VDC.



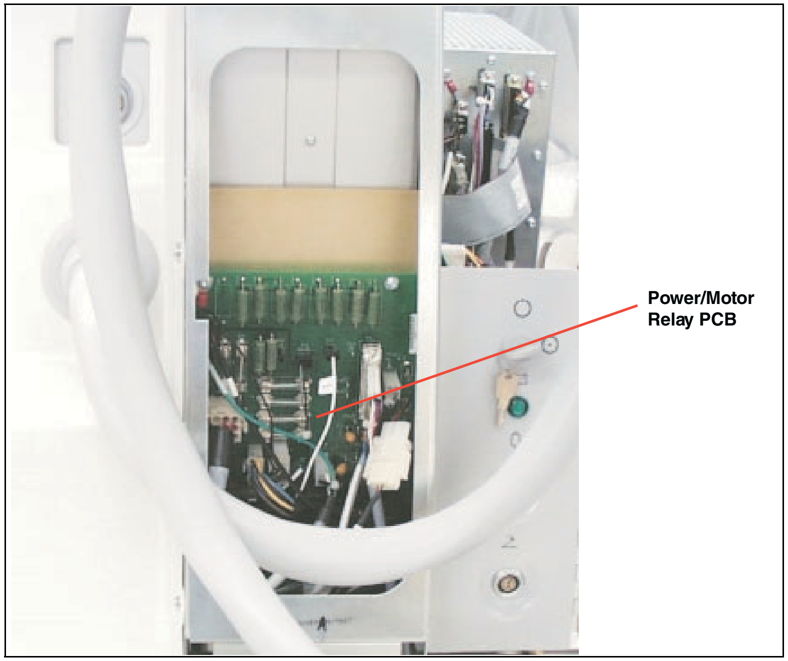
Column Power Supply PS3

Power/Motor Relay PCB

The Power/Motor Relay PCB, located under the generator's front cover, performs a variety of tasks, some of which are related to movement of the Vertical Column Lift. The Power/Motor Relay PCB is basically a slave to the X-Ray Controller PCB, and consists mostly of relays, LEDs, fuses, MOVs, resistors, capacitors, and other non-programmable devices.

The Power/Motor Relay PCB responds to signals from the X-Ray Controller PCB to power up the C-Arm in an orderly way. When the C powers up correctly, the Power/Motor Relay PCB permits movement of the Vertical Column by performing the following tasks:

- Applies 115 VAC to Column Power Supply PS3 in response to command from X-Ray Controller PCB.
- Responds to actuation of either Vertical Column Lift Button by applying +36 Volts to the LIFT_UP_SW or LIFT_DN_SW selector line on PS3. This causes the Vertical Column Lift to move up or down.
- Responds to actuation of either Fast Stop Switch by inhibiting X-rays and halting movement of the Vertical Column Lift.
- Serves as a passive distribution point for +12 and +24 Volts.

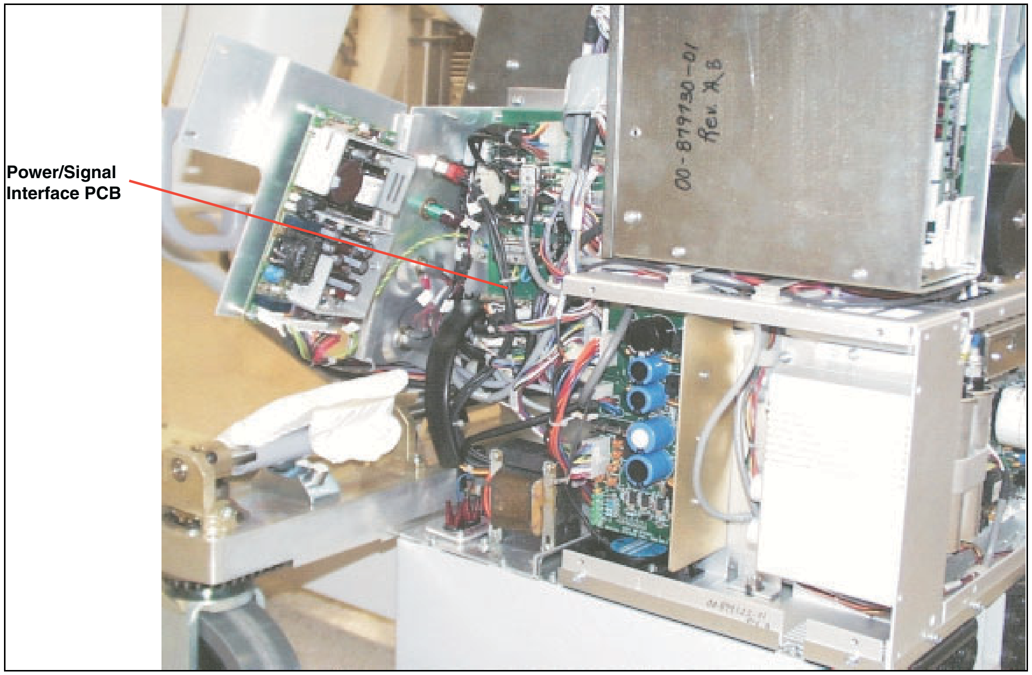

Power/Motor
Relay PCB

Power/Motor Relay PCB

Power/Signal Interface PCB

The Power/Signal Interface PCB routes +24 Volts from PS2 to the Power/Motor Relay PCB. This voltage operates the relays on the Power/Signal Interface PCB.   Fuse F11 protects this line. The fuse is rated at 3.15 amps and resides on the Power Signal Interface PCB.

The Power/Signal Interface PCB resides on the left-hand side of the generator as shown in the following illustration.

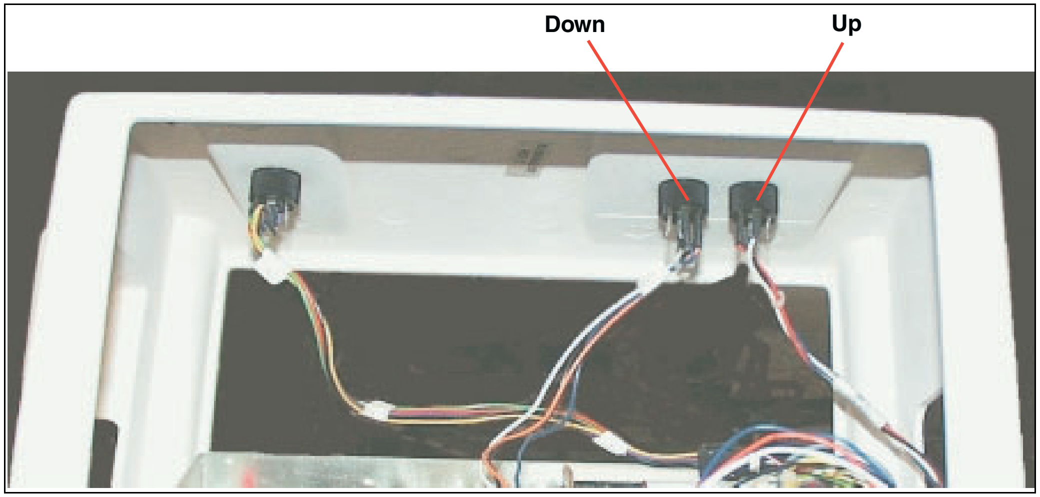


Power/Signal Interface PCB

Vertical Column Lift Buttons

The Vertical Column lift buttons mount on the Cross Arm Bearing cover, shown below.

Each Vertical Column lift pushbutton assembly consists of two ganged SPST momentary closure switches. Depressing either pushbutton closes both its switches. One closed switch actuates relays on the Power/Motor Relay PCB that supply 115 VAC to Column Power Supply PS3. The other closed switch contact connects 36 VDC from the Column Power Supply to its LIFT_UP_SW or LIFT_DN_SW selector line, depending on which Vertical Column lift button you press. The Column Power Supply responds to +36 volts on a selector line by supplying 24 VDC in the polarity required to drive the Vertical Column up or down.



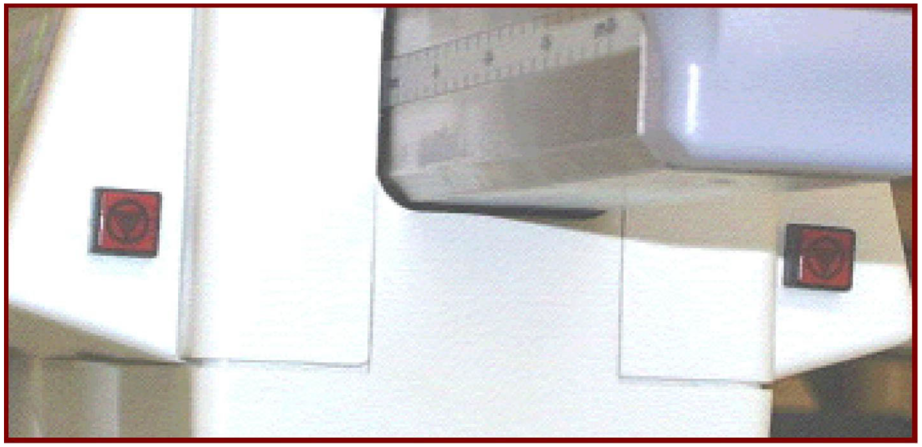
Vertical Column Lift Buttons

Fast Stop Switches

Press either Fast Stop switch to immediately halt movement of the Vertical Column and stop the C-Arm from generating X-Rays. There is one Fast Stop switch on each Control Panel assembly near the Horizontal Extension handle. These safety switches have red covers, making them easy to spot in an emergency. The Fast Stop switches do not light when you press them.

Each Fast Stop switch contains two ganged SPST, normally closed, momentary switches. Pressing either Fast Stop switch breaks the CPU Interlock circuit, disabling X-rays, and interrupts the +24 volts that operates the relays on the Power/Motor Relay PCB, cutting off AC power to the Column Power Supply and preventing Vertical Column movement.

Operation of either Fast Stop switch necessitates a reboot of the system. You must cycle power to the Workstation to continue.



Fast Stop Switches

Functional Test

1. Power up system and allow it to boot completely.
2. Press and hold the Up Vertical Column button. Verify that Vertical Column extends to its maximum height, and that it stops only when it reaches full extension.
3. Press and hold the Down Vertical Column button. Verify that Vertical Column lowers to its minimum height, and that it stops only when it reaches full retraction.
4. Verify that all Vertical Column movement is smooth and quiet.
5. Press and hold the Up Vertical Column button. While the Vertical Column moves upward, press one of the Fast Stop buttons. Verify that Vertical Column movement ceases, and that the Down Vertical Column button does not work.
6. Reset System and allow it to boot completely.
7. Press and hold the Down Vertical Column button. While the Vertical Column moves downward, press the other Fast Stop button. Verify that Vertical Column movement ceases, and that the Up Vertical Column button does not work.

Fault Isolation

Problem	Possible Cause	Possible Solution
Vertical Column movement button does not produce column movement or button's operation is intermittent	Faulty button	Inspect button and replace it if necessary.
	Faulty wiring between button and Power/Motor Relay PCB.	Look for loose or broken connectors or wiring. Repair or replace as necessary.
	+24 VDC not available to Power/Motor Relay PCB	Check for loose broken wires or connectors between P7 on Power/Motor Relay PCB and P8 on Power/Signal Interface PCB. Repair or replace as necessary
		Check fuse F11 on Power/Signal Interface PCB. Replace if necessary
		Check PS2 for +24 volts on P2-11. Refer to DC Power Distribution chapter for additional details on how to troubleshoot PS2.
	115 VAC not available to Power/Motor Relay PCB	Refer to AC Power Distribution chapter for troubleshooting help.
Column movement stops before column reaches maximum or minimum height	Obstacle in C-Arm's path	Remove obstacle
	Faulty Vertical Column	Replace Vertical Column (see *Replacement* chapter).
Column movement is noisy or rough	Faulty Vertical Column	Replace Vertical Column (see *Replacement* chapter).

Problem	Possible Cause	Possible Solution
Fast stop button does not halt stop column movement	Faulty Fast Stop button	Inspect button and replace it if necessary (see *Replacement* chapter).
	Faulty wiring or connector between button and P4 on Power/Motor Relay PCB	Inspect; repair or replace as necessary (see *Replacement* chapter)..
	Faulty Power/Motor Relay PCB	Inspect; replace if necessary (see *Replacement* chapter)..

Adjustment

The Vertical Column requires no periodic adjustment.

Miscellaneous

Not applicable.

Steering and Braking

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- Balance Wheel 6

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- Brakes 8
- Balance Wheel 8

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Circuit/Mechanical Descriptions

Four casters support the 9800 C-Arm. The front two casters are offset; the rear two casters are not (An offset caster is one that trails to the rear as the supported device moves forward, much like a wheel on a grocery cart.) There are two smaller casters at the front of the C-Arm and two larger casters at the rear. The larger rear casters are steerable and have internal brakes that keep the C-arm from rolling on inclines. A balance wheel at the rear of the C-arm is a safety feature that prevents the C-arm from tipping backwards on inclines or during maintenance.

Front Casters

The front casters rotate freely about the vertical axis, and automatically trail to the rear as you push the generator forward. The front casters have no brakes and are not steerable. The front casters are simple devices that support the front end of the C-Arm. They have sealed bearings and usually require no maintenance unless they are damaged. Refer to the Replacement section of this manual for instructions on how to install new front casters.

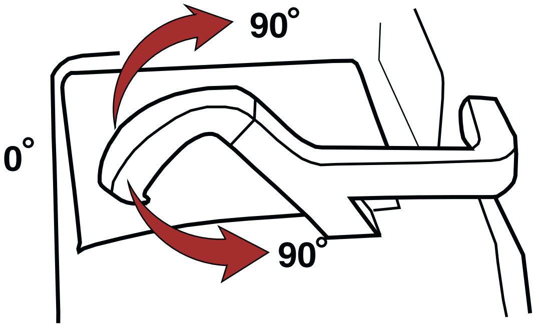
Front Casters

Rear Casters, Steering, and Brakes

Like the front wheels of a car, the C-Arm's rear casters are manually steerable. A chain drive connected to a steering shaft on a steering handle makes this possible, and ensures that the two rear casters track in the same direction.

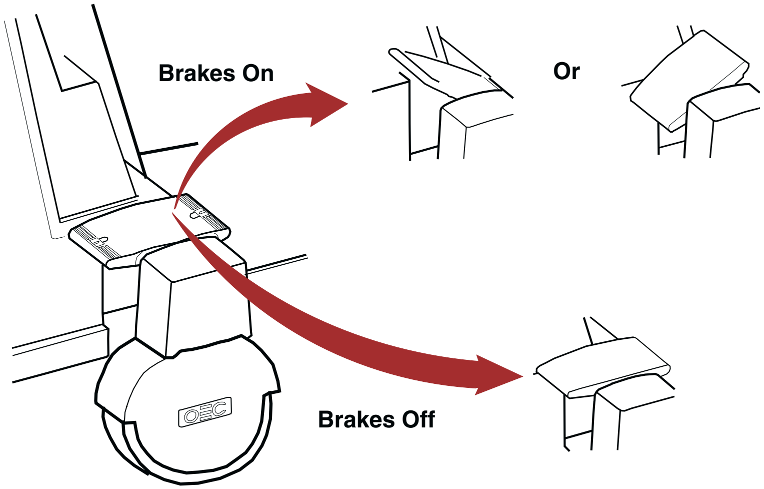
Rear Caster

You can steer both rear casters straight ahead when you move the C-Arm forward, or at any angle to move the C-Arm sideways. You can feel a mechanical detent in the steering handle arc that identifies the 90° left, 90° right, and straight ahead steering positions. The rear casters steer a maximum of 90 degrees left and right. There are also mechanical detents at 90 degrees left and right handle positions.



Steering Handle

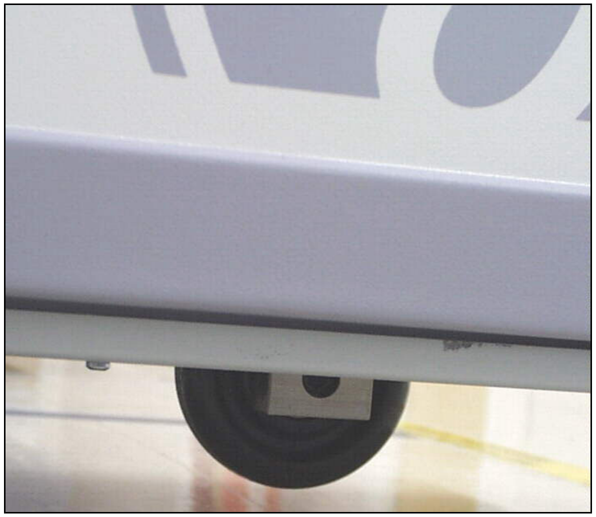
There is a brake pedal by each rear caster. Use either brake pedal to operate the friction brakes that immobilize both rear casters to keep the generator from rolling. Each rear caster has an internal brake mechanism that applies a brake pad to the caster to prevent it from turning. Tilt either pedal forward or backward to engage the brakes, or set either pedal to the level position to release the brakes. Both brake pedals mount on a common shaft that applies braking pressure through a roller cam to each rear caster. Refer to the Replacement chapter in this manual for information on how to install new brakes on the rear casters.


Brakes On
Or
Brakes Off
OEC

Brake Pedal Operation

Balance Wheel

There is a balance wheel at the rear of the C-Arm under the battery tray. The balance wheel is a safety device that normally does not contact the floor unless the generator tips backwards for some reason. This should not happen unless you remove the C from the generator for servicing purposes. The balance wheel is a low maintenance item with sealed bearings. It requires no periodic maintenance and does not require replacement unless it malfunctions or is damaged. Refer to the Replacement chapter in this manual for details on how to install a new balance wheel.



Balance Wheel

Functional Tests

Perform the following tests to verify correct operation of the C-Arm's suspension and steering components.

Front Casters

1. Verify that both front casters contact the floor and that they both roll freely.
2. Verify that both casters pivot freely on their vertical axles.
3. Make sure there are no worn or damaged areas on either caster tread.
4. Verify that there is no wobble or binding associated with either caster.

Rear Casters

1. Verify that both rear casters roll freely on the floor and that they pivot freely when you steer them right or left.
2. Make sure there are no worn or damaged areas on either caster tread.
3. Verify that there is no wobble or binding associated with either caster.

Steering

1. Verify that both rear casters respond appropriately to movement of the steering handle.
2. Verify that you can steer the rear casters 90 degrees to the left and 90 degrees to the right.
3. Verify that the casters track together when you steer them.
4. Verify that the steering handle detent for "straight ahead" engages as it should. The steering handle should click in place and remain in that position until you move it again.
5. Repeat step 4 for left and right steering handle detent positions.

Brakes

1. Step on either brake pedal, tilting it forward or backwards.
2. Verify that both rear wheels lock.
3. Step on either brake pedal, placing it in a level position.
4. Verify that brakes release and that both rear casters roll and steer freely.

Balance Wheel

Note: You need to get a clear look at both sides of the Balance Wheel when performing the following tests. If necessary, use a flashlight or some other light source.

1. Check the tread and both sides of the balance wheel for damage and other problems. Look for embedded debris, cuts, contamination, and excessive wear.
2. Verify that the balance wheel rotates smoothly and does not wobble or bind on the axle.

Fault Isolation

Note: Refer to Replacement chapter for instructions on how to replace suspension and steering parts.

Problem	Possible Cause	Solution
One front caster does not contact the floor	Caster that contacts floor is loosely mounted.	Inspect both casters and secure any loose mounting hardware.
	Caster that does not contact floor is bent or broken.	Inspect and replace as necessary.
Front caster does not pivot freely on vertical axis	Damaged axle parts.	Replace damaged axle parts.
	Axle parts are contaminated by debris.	Inspect and correct as necessary.

Problem	Possible Cause	Solution
	Axle parts require lubrication.	Inspect and lubricate as necessary.
Worn or damaged front caster tread	Careless or heavy use; damage from workplace hazard.	Replace caster and advise customer of any workplace hazards you discover.
Front caster binds or wobbles on axle bolt.	Worn caster bearing	Replace caster.
	Worn caster axle bolt.	Replace caster's axle bolt.
Rear caster does not roll freely on the floor.	Caster contaminated by debris.	Inspect and correct as necessary.
	Caster's bearing is dry.	Replace caster.
	Caster's axle bolt is worn or bent.	Replace caster's axle bolt.
Rear caster does not steer freely.	Damaged steering chain or worn steering sprocket.	Inspect and replace damaged parts as necessary.
	Steering chain or steering sprocket contaminated with debris.	Inspect and clean as necessary.
	Steering chain or steering sprocket requires lubrication.	Inspect and lubricate as necessary
Worn or damaged rear caster tread	Careless or heavy use; damage from workplace hazard.	Replace caster and advise customer of any workplace hazards you discover.
Brakes on one or both rear wheels do not engage.	Loose or broken roller cam or attaching hardware.	Inspect and tighten or replace if necessary.
	One or both brakes out of adjustment.	Perform adjustment as described in following paragraph.
Brakes do not release.	Damaged or loose brake part	Inspect and repair or replace brake part if necessary.
Balance wheel does not turn.	Balance wheel is contaminated with debris.	Inspect and clean as necessary.
	Balance wheel bearing is dry or damaged.	Replace balance wheel.

Problem	Possible Cause	Solution
	Balance wheel axle bolt is worn or damaged.	Replace axle bolt.
Balance wheel is loose on axle bolt or wobbles.	Damaged balance wheel.	Replace balance wheel
	Worn or damaged balance wheel axle bolt.	Replace axle bolt.
Worn or damaged balance wheel tread.	Careless or heavy use; damage from workplace hazard.	Replace caster and advise customer of any workplace hazards you discover.

Adjustment

The brakes in both rear casters wear during normal use. This gradually reduces their effectiveness. If you discover ineffective braking in one or both rear casters, first attempt to adjust the brakes in accordance with this procedure. If this does not restore normal braking action, you must inspect the brake parts and replace the worn ones as described in the Replacement section of this manual.

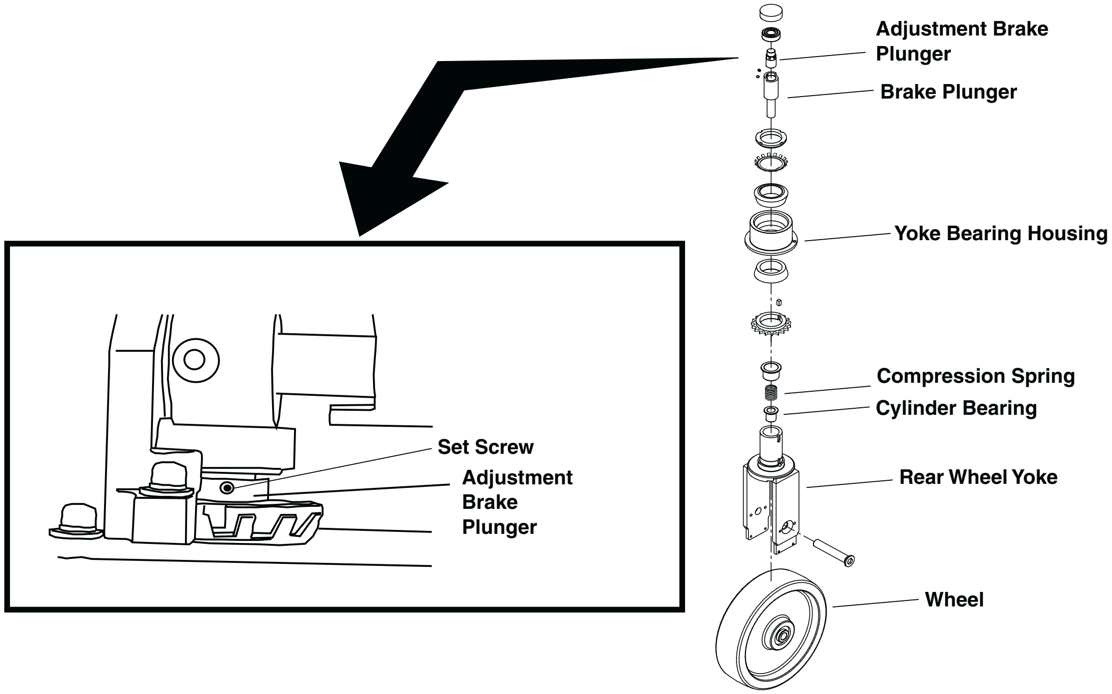
Follow these steps to adjust the brake in either rear caster (see next illustration):

1. Jack malfunctioning caster slightly so that wheel clears floor.
2. Release brakes and verify that caster rotates freely.
3. Remove end cap that covers brake's rolling cam actuator. Set end cap and its mounting screw aside.

Note: *Thread locking compound secures the two setscrews described in the following step. Turn these setscrews firmly to break them loose from the thread-locking compound.*

4. Loosen the two setscrews in the brake plunger.
5. Turn brake plunger adjuster until it extends out about an eighth of an inch further from the plunger.
6. Set brakes and check them for proper operation. If necessary, repeat step 5.
7. Secure setscrews when brake operates correctly, and apply thread-locking compound to setscrews to keep them from loosening.

8. Install end cap and screw you removed in step 3.
9. Remove jack from C-Arm axle and check brakes for proper operation.


Adjustment Brake Plunger
Brake Plunger
Yoke Bearing Housing
Set Screw
Adjustment Brake Plunger
Compression Spring
Cylinder Bearing
Rear Wheel Yoke
Wheel

Rear Wheel Brake Details

Miscellaneous

Not applicable.

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Troubleshooting Methods

This section is a brief troubleshooting guide for those who must identify and correct failures associated with the 9800 C-Arm. It presents proven troubleshooting methods and provides an overview of the tools available to the Field Service Engineer. It also describes solutions to actual problems experienced with fielded systems.

Bootup

The following paragraphs describe bootup events associated with the Series 9800 Mobile C-Arm. Most observable events consist of messages on the C-Arm Control Panel displays. The boot sequence can vary slightly from system to system depending upon configuration.

Time Required

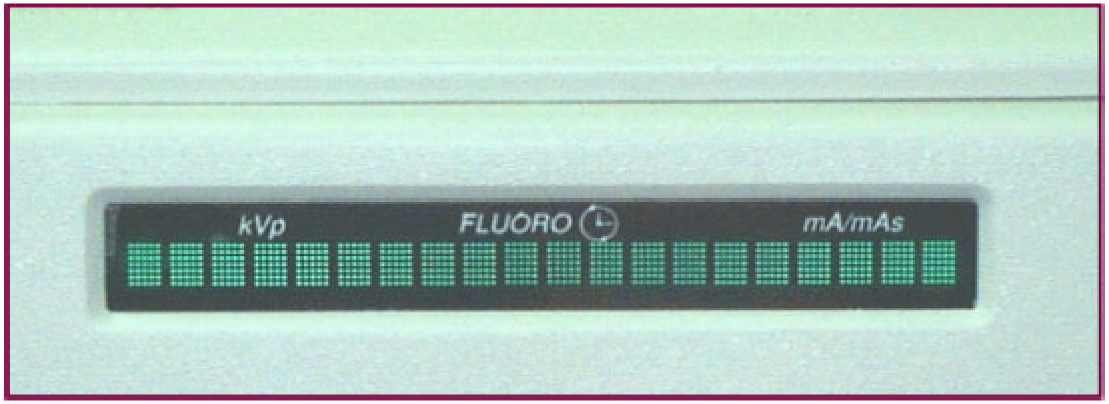
Normal boot-up time for the Series 9800 Mobile Imaging System is from 80 to 120 seconds depending upon configuration. Systems with WJ98 or later software loaded require 128 Meg of RAM on the Single Board Computer (SBC). The SBC Power-up Self Test requires longer to test the additional RAM in these systems than older systems with 64 Meg of RAM memory. If booting the 9800 system takes considerably longer than this, try to locate the source of the problem and correct it before releasing the system to the customer.

Boot Sequence Display on C-Arm Control Panel

The C-Arm Control Panel has a 20-character display that provides a visual indication of the C-Arm's progress in the boot sequence. The number of squares or arrows on the display indicates how far the bootup has progressed. If an error occurs during bootup, a message describing the error appears on the C-Arm Control panel displays at the conclusion of the boot sequence.

The 20-character display first shows a series of squares. The pattern is five squares, ten squares, 15 squares, and 20 squares. The pattern repeats once.

Arrows appear on the 20-character display after the squares. It is possible that if an error occurs within the first three arrows, a hardware problem may exist that will prevent you from loading software from the IDE hard drive. It will not be possible to load new software because the C-Arm has to boot completely for the Remote Utilities (RUT) to work. It may be necessary to start the system from the boot disk and troubleshoot the system.



C-Arm Control Panel Boot Sequence Display (Squares)

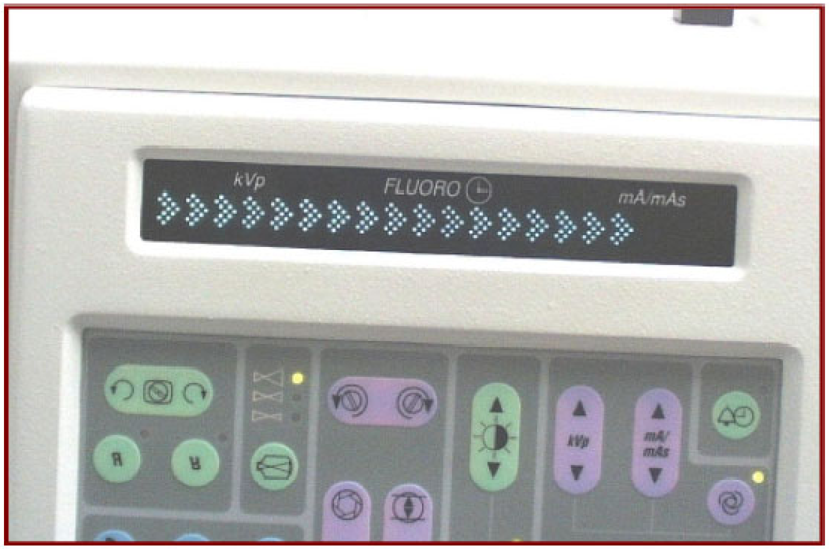
The bootup squares have the following meaning:

Five Squares: Initialization of interrupts, display, and timers is complete.

Ten Squares: EEPROM checksum verification is complete.

15 Squares: Keyboard initialization is complete.

20 Squares: Control Panel Processor PCB’s UART initialization is complete. Control Panel Processor has sent its “boot complete” message to the Fluoro Functions PCB.



C-Arm Control Panel Boot Sequence Display (Arrows)

The bootup arrows have the following meaning:

No Arrows: The operating system begins loading. If bootup fails on this arrow, reload the software.

One Arrow: ARCNet initializes. Software architecture initializes. System sets C-Arm time. If bootup fails on this arrow, check ARCNet connection on the Fluoro Functions PCB and X-ray Controller PCB. Reload software.

Two Arrows: The system performs a CRC on persistent (non-volatile) data. If bootup fails on this arrow, reload the software.

Three Arrows: Internal software timers initialize. If bootup fails on this arrow, reload the software.

Four Arrows: Operating system completes loading. General application software starts (Gen_Init). If bootup fails on this arrow, check ARCNet connections on Fluoro Functions PCB and X-Ray Controller PCB. If Workstation completes boot, check System Interface PCB. Reload software.

Five Arrows: Generator object tasks initialize. If bootup fails on this arrow, check communications between Workstation and C-Arm. Check the ARCNet. Verify that Workstation completely boots.

Six Arrows: All generator objects have been created and relationships formalized. Communications between Workstation and C-Arm have been established. If bootup fails on this arrow, reload the software.

Seven Arrows: Error handlers initialize. If bootup fails on this arrow, reload the software.

Eight Arrows: System reads and sets CMOS values. If bootup fails on this arrow, check CMOS and reload software.

Nine Arrows: System checks generator event table and loads it into memory. If bootup fails on this arrow, check flash memory and reload software.

Ten Arrows: PIOs initialize. If bootup fails on this arrow, check registers and counters, and reload software.

11 Arrows: System checks analog-to-digital converters for errors. If bootup fails on this arrow, reload software.

12 Arrows: System initializes generator bridge data. If bootup fails on this arrow, reload software.

13 Arrows: System loads duty cycle table into memory. If bootup fails on this arrow, check communications between the Workstation and C-Arm. Check flash memory. Check GEN_PO.bin file on Workstation.

14 Arrows: System check ABS table and loads it into memory. If bootup fails on this arrow, check communications between the Workstation and C-Arm. Check flash memory. Reload software.

15 Arrows: Stator ramps. If bootup fails on this arrow, check Stator circuit breaker and circuitry. Also check Generator Events Log.

16 Arrows: Precharge complete. If bootup fails on this arrow, check Precharge circuitry, Generator Events Log, and Battery circuit breaker.

17 Arrows: Filament ramps. If bootup fails on this arrow, check Filament drive circuitry on Filament Driver PCB and Generator Driver PCB.

18 Arrows: System checks C-Arm battery. If bootup fails on this arrow, check Generator Events Log, C-Arm batteries, and INV_B_SEN signal on Filament Driver PCB and Generator Driver PCB.

19 Arrows: WS X-Ray Enabled. Workstation completed boot-up sequence and it’s OK to take X-rays. If boot-up fails on this arrow, check the workstation and ARCNet communication between workstation and generator.

20 Arrows: Bootup complete (does not display).

Generator Defaults

After normal bootup, the C-Arm defaults to the following conditions:

- Alarm Reset is OFF.
- Automatic contrast and brightness are ON.
- Auto technique is ON.
- Camera iris is OPEN.
- Collimator leaves are OPEN.
- The Collimator is not rotated.
- Film mode is OFF.
- Low Dose is OFF.
- Magnification is NORMAL.
- Camera rotation is set to customer specification.
- Invert top to bottom is OFF.
- Reverse left to right is OFF.
- Pulse mode is OFF.

C-Arm Control Panel VFD Messages

There are five kinds of messages that appear on the C-Arm Control Panel Vacuum Fluorescent Displays:

1. A **Timed** message appears for a set time and then disappears.

2. An **Alternating** message appears for two seconds, followed by the technique, which appears for two seconds. The pattern repeats.

3. A **User Input Required** message won't leave the C-Arm Control Panel display until you enter the information being requested.

4. A **Disables X-Rays** message prevents the generator from producing X-rays.

5. A **System Shutdown** message appears when software prevents the generator from working.

The following is an alphabetized list of messages that can appear on either C-Arm Control Panel display during initialization or operation of the Series 9800 Mobile Digital Imaging System. These messages advise you of processing being done, notify you of errors, and provide warnings to prevent personal injury or equipment damage.

4-HOUR WARM-UP REQUIRED - PRESS ANY KEY - This message appears when the system has been inactive for more than 60 days. The four-hour delay is necessary for ion removal from the Image Intensifier. All generator functions are disabled during this period. Press any C-Arm key to continue after the four-hour warm-up is complete.

24-HOUR RECHARGE REQUIRED - X RAYS DISABLED - This message appears when the C-Arm batteries need recharging, typically after long-term storage of six months or more. All generator functions are disabled during this period. Leave the Workstation power cord plugged in, make sure the interconnect cable is properly connected, and wait 24 hours before use. It is not necessary to turn the Workstation on.

AD CHANNEL %s FAIL – POWER OFF. WAIT 5 SECONDS - You will see this message when an analog-to-digital channel fails during system start-up. The actual channel number appears in place of the pound sign. Analog-to-digital channel failure causes total shutdown of the system. First, reboot the system, leaving power off for five seconds. If the failure reappears, refer to *A/D Channel Failure* in this section for detailed troubleshooting information.

ANODE IS HOT - XX% - This error message appears when the X-ray tube is at 80% (+ 2%) of its rated capacity or greater. XX is the actual percentage of capacity. The message alternates with the technique and an alarm sounds.

TO PREVENT DAMAGE TO THE X-RAY TUBE, ALLOW IT TO COOL BEFORE MAKING ANOTHER EXPOSURE. The system blocks HLF and FILM shots. You can silence the alarm by pressing the **ALARM RESET** key.

ANODE IS WARM - XX% - When the X-ray tube is at 70% (+ 2%) of its rated capacity, you will see this error message alternating with the technique. XX is the actual percentage of capacity. The system displays this message as a warning only, and does not restrict HLF or film shots. To prevent damage to the x-ray tube, allow it to cool before making another exposure.

DANGER: *Ignoring this warning can cause damage to the X-ray tube, cooling bladder, and may result in patient burns.*

BATTERY CHARGE - XX% - The system displays this message alternating with the technique when the C-Arm batteries are at 70% to 40% of the required charge. XX is the actual charge percentage, which the system displays in the message. Fluoro, Film, and HLF exposures are still allowed. To charge the batteries, leave the system plugged into an active AC receptacle with the Interconnect Cable in place between the C-Arm and the Workstation.

BATTERY CHARGE - XX% /WAIT - The system displays this message alternating with the technique when the C-Arm batteries are below 40% of their required charge. XX is the actual charge percentage, which the system displays in the message. The WAIT message appears in the center of the technique display. Fluoro exposures are allowed, but Film and HLF exposures are not allowed until the battery has recharged. To charge the batteries, leave the system plugged into an active AC receptacle with the Interconnect Cable in place between the C-Arm and the Workstation.

CAMERA IRIS FAILURE

CHARGER FAILED - This message appears alternating with technique when the Battery Charger fails during bootup.

CHARGER FAILED – POWER OFF – WAIT 5 SECONDS

COLL IRIS POTENTIOMETER ERROR - PRESS ANY KEY - You will see this message when the position potentiometer on the collimator is not working or is disconnected. Until you clear this message, all generator functions including X-rays are disabled. If problem persists, check position sense line COLL_IRIS_POSN on the Fluoro Functions PCB. This line should transition as the collimator iris moves.

COLL IRIS TOO LARGE - This message appears alternating with the technique when the aperture in the Collimator iris is larger than indicated on the C-Arm Control Panel.

COLL IRIS UNSTABLE - This message appears alternating with the technique on both C-Arm Control Panel displays when the collimator iris motor cannot maintain position tolerance, usually because it's jittery. You may continue to use the system, although the iris instability may degrade the image at the edges of the X-ray field.

COLLIMATOR CAL REQUIRED - PRESS ANY KEY - This message appears if the collimator's iris and leaf position values do not match the reference values stored in memory. All generator functions including X-rays are disabled until you clear this problem. First, clear the message by pressing any key on either C-Arm control panel. If the message persists, recalibrate the Collimator and restart the system. (See *Calibration* section in this manual.)

COLLIMATOR STUCK - You will see this message alternating with the technique when the Collimator iris motor can't open or close the iris. The message appears on both C-Arm Control Panel displays alternating with the technique. You can continue to use the system, although you won't be able to adjust the Collimator iris.

COMMUNICATION FAILED – This message occurs when the Workstation hasn't communicated with the C-Arm for more than 1 second, allowing the C-arm Watchdog circuitry to "time out". This problem has occurred in the past as a result of foot pedal "toe tapping" (repeatedly pressing the foot pedal and releasing too quickly), as well as repeated random control panel button pressing. The error can also occur when Workstation software encounters an exception, or anomalous condition in which it spends excessive time executing specific routines and does not send updates to the C-arm. When this error occurs, the system finishes any X-ray in progress, and disables future X-rays. First, turn the system off for at least five seconds and restart it. If the problem persists, check the functionality of the system and check the ARCNET communications. Frequent Communication Failed errors may also be indicative of corrupted persistent object files, which may require a software reload.

CONTROL PANEL ERROR - The system generates this message when it cannot communicate with the C-Arm Control Panels. The message never appears on the C-Arm Control Panel displays, but the system logs it in the Generator Error log. This error causes the system to immediately shut down. First, turn the system off for at least five seconds and restart it. Next, check the functionality of the system and check the ARCNET.

CONTROL PANEL KEY STUCK - RELEASE, THEN PRESS ANY KEY TO CONTINUE - The system generates this message when a C-Arm Control Panel key is stuck on at bootup. This disables all generator functions, including X-rays, until you correct the sticky problem key and clear the message.

DATA ERROR - This message appears when the system detects a data error. This can be an invalid write to an ABS table, an invalid read from an ABS table, corrupted data in non-volatile memory, a software problem, etc. Data errors shut the system down.

FAST STOP ACTIVATED – POWER OFF. WAIT 5 SECONDS. - This message appears when the Interlocks are open. This is typically the result of pressing either **FAST STOP** switch on the front of the C-Arm Control Panel. This condition disables X-ray generation and most system functions, including column lift motors. You must power the system down, wait 5 seconds and reboot to resume operation. If the problem persists, the 24V interlock loop has most likely been broken.

FILAMENT CAL REQUIRED - PRESS ANY KEY - This message appears at system startup if the software detects that a filament calibration has not been performed on the system. It is possible to receive multiple mA errors as a result of this condition.. This error disables the generator. Press any C-Arm Control Panel key to re-enable the generator and clear the message. If the message persists, use RUT to perform a filament calibration.

FILAMENT REGULATOR FAILURE - PRESS ANY KEY - This message appears when the system senses that the Xray tube filament current is out of tolerance. You may press any C-Arm control panel key to continue. However, the resolution of future images may be degraded. If problem persists, check filament regulator circuitry.

FILAMENT SELECT ERROR - PRESS ANY KEY - This message appears when the filament size selected in the software does not match the current filament in the PIO hardware. Press any C-Arm control panel key to continue. X-rays are disabled while this error is active. If problem persists, check filament select circuitry.

FILAMENT STANDBY

FLUORO ALARM

FOOTSWITCH SECURITY ERROR - This message appears when the X-ray security line does not match the X-ray control. This error applies only to the Left or Right X-ray controls. This error condition shuts down the system.

HLF OVERTIME - This message appears when a Digital Cine run or High Level Fluoro (HLF) has exceeded the preset time and has been terminated. An audible alarm sounds when this message appears, and X-rays in progress terminate. This is a safety precaution to prevent excessive patient X-ray dosage. Release the X-ray control to clear the message, silence the alarm, and re-enable X-rays.

HOUSING IS HOT-XX% - You will see this message alternating with the technique when the X-ray tube is at 80% or more of its rated capacity. XX represents the actual heat rating percentage, and is part of the message. An audible alarm sounds when this message appears. HLF and Film shots are blocked and disabled at this temperature. You can silence the audible alarm by pressing the **ALARM RESET** key.

DANGER: *Although fluoroscopy is not prevented when you get this error message, you MUST wait for the tube to cool before making another exposure. Ignoring this warning can cause damage to the X-ray tube, cooling bladder, and may result in patient burns.*

HOUSING OVERHEATED - This message appears when the X-ray tube is at 100% or more of its rated capacity. The thermal cutoff switch activates, shutting down the system immediately. Let the housing cool before attempting to operate the system. Adequate cooling may require an hour or more.

HOUSING WARM-XX% - This message appears when the X-ray tube is at 70% (+ 2%) of its rated capacity. XX represents the actual heat rating percentage, which is part of the message.

HV GENERATOR ERROR - You will see this message when the system detects an error in any of the registers associated with the high voltage generator. The system shuts down when this error occurs. If this message persists, check the HV drive and flux sense circuitry on the Generator Driver PCB and High Voltage Supply Regulator PCB.

HV REGISTER FAIL - This message appears when the system detects an error in any of the high voltage generator registers at startup. The system shuts down when this error occurs.

INTERLOCK FAILURE - This message appears when the system determines that the interlock circuits are in an incorrect state during power up. The system shuts down when this error occurs.

KEY STUCK - RELEASE, THEN PRESS ANY KEY TO CONTINUE - This message appears when the system senses a key closure on the C-Arm Control Panel during boot-up, possibly indicating a stuck key. Verify that there are no objects pressing against either Control Panel. After releasing a stuck key, press any C-Arm control panel key to continue. A malfunctioning control panel key may interfere with operation if you attempt to continue.

KEY SWITCH IN STANDBY - X-RAYS AND LIFT DISABLED - This message appears when the X-ray disable keyswitch on the generator is turned on (key handle vertical) , preventing movement of the vertical column and generation of X-rays. Place the key handle in the horizontal position to enable X-rays and vertical column movement. If the keyswitch is already in the ON position, there may be a fault in the keyswitch or other associated hardware.

KV ON IN ERROR - This message appears when the system detects that the X-ray tube current is on, but no X-ray switch is pressed. The system shuts down immediately.

LIFT SWITCH STUCK - PRESS ANY KEY - You will see this message when either C-Arm lift switch has been in the ON condition for 30 seconds or more. All generator functions are inhibited until you press any C-Arm Control Panel key clear this message. If the message persists, look for something pressing on the switch, a faulty switch, or a faulty lift circuit.

LOADING LOW DOSE ABS - This message appears when you select the Low Dose ABS table as the current ABS table in the generator.

LOADING STANDARD ABS - This message appears when you select the Standard ABS table as the current ABS table in the generator.

MA ON IN ERROR - The system displays this message when mA Sense is on and no X-ray switch is activated. This error shuts the system down completely.

MA SENSOR FAIL - This message appears alternating with technique when the system detects a failure in one of the mA sensors. If message persists, check HV tank sense points, and check the HV Supply Regulator PCB.

OVERLOAD FAULT - This message may indicate a fault in the high voltage regulator circuit. The first time this fault occurs, the message appears only briefly after an exposure. The second time this fault occurs, the system automatically shuts down and the message remains on display. If message persists, look for excessive current in the series-tuned circuit inductor (L1), and check for a HV tank or X-ray Tube arc.

OVERVOLTAGE FAULT - This message may indicate an X-ray generator failure. The first time this fault occurs, the message appears only briefly after an exposure. The second time this fault occurs, the system automatically shuts down and the message remains on display. If message persists, look for excessive current in the series-tuned inductor (L1), and check for a HV tank or X-ray Tube arc.

PLEASE WAIT - This message appears while the system performs internal processing. X-rays are disabled during this period.

PRECHARGE CIRCUIT TIMEOUT - This message indicates the CONTACT relay failed to close during the startup process. This fault causes the system to shut down.

PRECHARGE VOLTAGE ERROR - This message appears when the voltage on the generator's precharge capacitors exceeds 250 Volts. This voltage check occurs during bootup, and shuts down the system immediately if there is a problem. This error can occur if the system has been connected to AC but unused for a long period of time, in which the batteries become overcharged. Draining some charge from the batteries has been shown in the past to correct this error.

RELEASED EARLY - The system displays this message in Film mode when the X-ray control is released before the film is properly exposed. The message automatically clears from the C-Arm Control Panel displays after two seconds.

ROOM DOOR OPEN – CLOSE DOOR –Door of X-ray room is open.

RUNNING CALIBRATION - This message appears when the Remote Utilities Tool (RUT) software calibrates the generator filament.

SATURATION FAULT - This message indicates a fault in the high voltage regulator circuit. The system will not operate with this error. If message persists, look for excessive current in the IGBTs, and check the HV drive circuitry.

STATOR NOT ON - The system generates this message when it determines that the X-ray tube anode is not powered. This error causes the system to shut down.

STATOR STANDBY

WAIT - This message appears when the system detects that the batteries are below 40% capacity. The system displays the message between kV and mA where the accumulated exposure time normally appears. Allow the batteries to charge until this message disappears.

WARNING, HIGH KV - PRESS ANY KEY - The system generates this message when the actual kVp being produced is higher than the amount shown on the C-Arm Control Panel display, and is not within tolerance. If message persists, check HV drive circuitry and kVp sense circuitry.

WARNING, HIGH MA - PRESS ANY KEY - The system produces this message when the actual mA is higher than the amount shown on the C-Arm Control Panel display, and is not within tolerance. If message persists, check filament drive circuitry and mA sense circuitry.

WARNING, LOW KV - PRESS ANY KEY - The system generates this message when the actual kVp being produced is lower than the amount shown on the C-Arm Control Panel display, and is not within tolerance. Lower kVp may result in poor image quality. If message persists, check HV drive circuitry, and the kVp Sense circuitry.

WARNING LOW MA - PRESS ANY KEY - The system generates this message when the actual mA being produced is lower than the amount shown on the C-Arm Control Panel display, and is not within tolerance. Lower mA may result in poor image quality. If message persists, check filament drive circuitry, and mA Sense circuitry.

X-RAY OVERTIME - PRESS ANY KEY - The system produces this message when a film shot continues beyond the required exposure time, and software terminates the exposure. Press any C-Arm Control Panel key to continue. This message is a safety precaution to prevent excessive patient X-ray exposure.

X-RAYS DISABLED

X-RAY SWITCH SECURITY ERROR - The system produces this message when there is a mismatch between the Security line on the footswitch or handswitch, and the Security line on the matching connector. If problem persists, check footswitch and handswitch for incorrect wiring, and check the X-Ray Controller PCB.

X-RAY SWITCH STUCK - The system generates this message when it senses an X-ray control in the ON state during system startup. This error applies only to the Left or Right X-ray controls, and causes the system to shut down. Verify that the switch is not being held down. Disconnect handswitch and/or footswitch and restart the system. If the system restarts without failure, the disconnected device may require service. If message persists with handswitch and/or footswitch disconnected, there is an internal fault that is preventing proper system operation.

X-RAY TUBE TEMPERATURE SENSOR FAILURE - PRESS ANY KEY - This message appears when the X-ray tube’s temperature sensing thermistor fails functional testing at start-up. You may continue using the system, but there is a danger that the X-ray tube may overheat during use without further warnings being given. Overheating may cause X-ray tube or cooling bladder damage, which may result in patient burns. The message remains on the C-Arm Control Panel displays, and the generator is disabled until you press any C-Arm Control Panel key.

A/D Channel Failure

If an analog-to-digital channel failure occurs, the message AD CHANNEL # FAIL appears on the C-Arm Control Panel displays.

The analog-to-digital converter is located on the X-Ray Controller PCB. It consists of op amps, a 16-channel mux (U48), a unity-gain op amp, and a 12-bit A/D converter that has an input range of about 10 Volts. U36 provides a 2.5 Volt reference for the A/D converter. Buffer U27 reads the data from the A/D converter.

All A/D channels and their associated signals can be probed on the X-Ray Controller PCB.

Channel #	Message	Signal Name	Pin and Reference
0	Housing Temperature	HSNG_TEMP	P1-85, 86
1	Stator Sense	STATOR_SEN	P1-108, 109
2	Spare; not used	None	None
3	Filament B	FIL_B_SEN	P1-50, 51
4	Flux Sense	FLUX_SEN	P1-56, 57
5	Filament Current	FIL_CUR	P1-52, 53
6	Filament Voltage	FIL_VOLT	P1-54, 55
7	Charge Current	CHRG_I_SEN	P1-78, 80
8	Line Voltage	LINE_V_SEN	P1-75, 80
9	kVp	KVP_SEN	P1-72, 73
10	Low mA	LO_MA_SEN	P1-70, 71
11	High mA	HI_MA_SEN	P1-68, 69
12	Inverter B	INV_B_SEN	P1-48, 49
13	kVp Feedback	KVP_CTL	P1-24, 25
14	Filament B Feedback	FIL_B_CNTL	P1-37, 38
15	Test DA Sense	TEST_DA	U34-7

Generator Processing

The generator performs a number of processing activities under program control. The following paragraphs discuss these processes.

Filament Control

There are two filaments in the X-ray tube, the “large” filament and the “small” filament. System software ensures that only one filament is on at a time. It also determines which filament is selected, preheats it, and determines the duty cycle.

Stator Control

The X-ray tube's anode must rotate whenever the system generates X-rays to prevent damage to the anode. System software rotates the anode by applying start and run voltages to the stator winding on the X-ray tube. It also removes the run voltage from the stator winding when there have been no inputs to the system for five minutes, and places a message in the **Generator Events** log when this occurs. Software monitors a stator sense line to make sure the anode is turning when it should be, and displays an error message if it is not.

Heat Calculations

Software performs regular checks on the X-ray tube anode and X-ray tube housing to prevent damage from high temperatures. This monitoring occurs both during and after X-rays. Software calculates anode temperature based on technique and duty cycle, and monitors a hardware thermistor on the X-ray tube housing. Since anode temperature cannot be measured directly and must be calculated, it is possible to "fool" the software under certain circumstances by removing and reapplying system power while the anode temperature is high. This may result in miscalculation of anode temperature and subsequent overheating.

Management Functions

System software manages several C-Arm functions, as described in the following paragraphs.

Disable X-Rays

Software monitors the state of the **X-Ray Enable Keyswitch** and several other parameters to determine when to disable X-rays. When X-rays are disabled, software generates a message describing the reason why on the C-Arm Control Panels.

Perform Technique Lock

System Software asserts Technique Lock to prevent changes to kV, mA, and CCD Camera gain. Technique Lock also disables ABS servo. Disabling Technique Lock causes the software to begin automatic adjustment of kV, mA, and Camera Gain while in Auto Fluoro mode.

Accumulate Exposure Time

Software maintains an accumulated exposure time for the current patient. This time appears on each C-Arm Control Panel centered between kV and mA when the system is in Manual or Auto Fluoro mode. You can manually reset the exposure time, or let it reset automatically when the system boots or when the current patient changes.

C-Arm Events Log

System software logs generator events and corresponding data to the Generator Events Log. This is valuable information that has great troubleshooting value. When an error message appears on the C-Arm's Control Panel Display, use RUS/RUT to access the Generator Events Log and review the messages there. Refer to the program help file for information on RUS/RUT program operation. Besides listing the generator event, each message includes one or two data items. Following is an alphabetized list of all possible messages:

Message	Type or Code	Data Item
AD CHANNEL %s FAIL – POWER OFF – WAIT 5 SECONDS	Error	1-Channel number 2-Scaled A/D Value
ANODE IS HOT	Error	1-Percentage of Capacity 2-Heat Units in kilo-units
ANODE IS WARM	Error	1-Percentage of Capacity 2-Heat Units in kilo-units
HLF OVERTIME	Operation	1-None 2-None
FILAMENT CAL REQUIRED	Error	1-None 2-None
CAMERA IRIS FAILURE	Error	1-0 = open; 1 = close 2-None
PRE-CHARGE VOLTAGE ERROR – POWER	Error	1-Battery Voltage (Inverter B A/D)

Message	Type or Code	Data Item
OFF – WAIT 5 SECONDS		2-None
CHARGER FAILED	Error	1-Battery Voltage (Inverter B A/D) 2-Charge Current (Charger I Sense A/D)
CHARGER FAILED – POWER OFF – WAIT 5 SECONDS	Error	1-Battery Voltage (Inverter B A/D) 2-Charge Current (Charger I Sense A/D)
BATTERY CHARGE - ##%	Error	1-Percentage of Capacity 2-Battery Voltage (Inverter B A/D)
COLLIMATOR CAL REQUIRED – PRESS ANY KEY	Error	0 = Leaves; 1 = Iris; 2 = Leaves and Iris 2-None
COLL IRIS UNSTABLE	Error	1-Pot reading 2-None
COLL IRIS POTENTIOMETER ERROR – PRESS ANY KEY	Error	1-Pot reading 2-None
COLLIMATOR STUCK	Error	1-Pot reading 2-None
COLL IRIS TOO LARGE	Error	1-Pot reading 2-None
COMMUNICATION FAILED		1-None 2-None
CONTROL PANEL ERROR	Error	1-None 2-None
DATA ERROR	Error	1- 0 = Program Area 1 = Data Area

Message	Type or Code	Data Item
		2-0 = Flash corrupted 2- 1 = Workstation corrupted 2 = Flash and Workstation corrupted 3 = Workstation new than flash 4 = Flash newer than Workstation 5 = Generator event flash corrupted 6 = ABS flash corrupted 7 = ABS download failed 8 = General Protection Fault (random pointer) 9 = Altered persistent data 10 = Duty Cycle table is missing or corrupt 11 = CMOS and flash is not initialized 12 = CMOS data out of range - Offset # 13 = No error message file
HLF OVERTIME (digital cine)	Operation	1-None 2-None
FILAMENT REGULATOR FAILED	Error	1-Filament V 2-None
FILAMENT SELECT ERROR – PRESS ANY KEY	Error	1-Correct filament: 0 = Small; 1 = Large 2-None
FILAMENT STANDBY	Operation	1-None 2-None
X-RAY SWITCH SECURITY FAILURE	Error	1-X-ray switch register 2-None
X-RAY SWITCH STUCK	Error	1-X-ray switch register 2-None

Message	Type or Code	Data Item
HOUSING IS HOT - ##%	Error	1-Percentage of Capacity 2-Heat Units in kilo-units
HOUSING WARM - ##%	Error	1-Percentage of Capacity 2-Heat Units in kilo-units
HOUSING OVERHEATED	Error	1-Percentage of Capacity 2- Heat Units in kilo-units
HV GENERATOR ON	Error	1-High Voltage Input Register Reading 2-None
HV REGISTER FAIL	Error	1-Register Address 2-Register Reading
INTERLOCK FAILURE	Error	1- 0 = Interlock failed to close; 1 = Interlock already closed; 3 = Interlock IO_ILK task missing 2-None
FAST STOP ACTIVATED – POWER OFF. WAIT 5 SECONDS	Operation	1-High Voltage Input Register reading 2-None
RELEASED EARLY	Operation	1-None 2-None
KEY STUCK – RELEASE, THEN PRESS ANY KEY TO CONTINUE	Error	1-None 2-None
WARNING – HIGH kV – PRESS ANY KEY	Error	1-Sensed kV 2-Desired kV
WARNING – LOW kV – PRESS ANY KEY	Error	1-Sensed kV

Message	Type or Code	Data Item
		2- Desired kV
KV ON IN ERROR – POWER OFF, WAIT 5 SECONDS	Error	1-Sensed kV 2-None
LIFT SWITCH STUCK – PRESS ANY KEY	Error	1-None 2-None
WARNING, HIGH MA – PRESS ANY KEY	Error	1-Sensed mA 2-2-Desired mA
MA SENSOR FAIL	Error	1-Sensed mA 2- Desired mA
WARNING, LOW MA – PRESS ANY KEY	Error	1-Sensed mA 2-Desired mA
MA SENSOR FAILE	Error	1-Sensed mA 2-Desired mA
MA ON IN ERROR – POWER OFF, WAIT 5 SECONDS	Error	1-Sensed mA 2-None
OVERLOAD FAULT	Error	1-High Voltage Input Register reading 2-None
OVERVOLTAGE FAULT	Error	1-High Voltage Input Register reading 2-None
PLEASE WAIT	Operation	1-None 2-None
PRECHARGE CIRCUIT TIMEOUT – POWER OFF. WAIT 5 SECONDS	Error	1-Inverter B (Battery Voltage) 2-None
24 HOUR RECHARGE REQUIRED – X-RAYS DISABLED	Error	1-Inverter B (Battery Voltage) 2-None

Message	Type or Code	Data Item
SATURATION FAULT – POWER OFF. WAIT 5 SECONDS	Error	1-High Voltage Input Register Reading 2-None
STATOR NOT ON – POWER OFF. WAIT 5 SECONDS	Error	1-High Voltage Input Register Reading 2-None
STATOR STANDBY	Operation	1-None 2-None
TEMP. SENSOR FAIL	Error	1-Thermistor reading 2-None
4 HOUR WARM UP REQUIRED – PRESS ANY KEY	Operation	1-None 2-None
XRAY OVERTIME – PRESS ANY KEY	Error	1-Inverter B (Battery Voltage) 2-Filament Voltage
KEY SWITCH IN STANDBY – X-RAYS AND LIFT DISABLED	Operation	1-None 2-None
XRAYS DISABLED	Error	1-None 2-None
ROOM DOOR OPEN – CLOSE DOOR	Operation	1-None 2-None

ARCNet Waveforms

Nodes

The ARCNet is the primary control path in the Series 9800 Mobile Digital Imaging system. The path consists of four ARCNet nodes, as follows:

1. Two nodes in the C-Arm, located on the following PCBs:
    a. Fluoro Functions PCB.
    b. X-Ray Controller PCB.
2. Two nodes in the Workstation, both located on the System Interface PCB, which in turn occupies an ISA slot on the Host CPU motherboard. These nodes are called the following:
    a. 9800 System ARCNet host, or **Workstation** node.

       This node has two junctions. The first junction communicates with any external ARCNet devices that may be connected to the Workstation rear panel. The second junction provides ARCNet communication to the C-Arm through the Interconnect cable.

    b. Remote Diagnostics Gateway, or **Service** node.

       This node provides a data pathway between the system ARCNet and an external modem.

ARCNet Waveforms

You can use a digital oscilloscope to observe ARCNet signals anywhere on the ARCNet bus. It is most convenient on the C-Arm, where you can place either the Fluoro Functions PCB or X-Ray Controller PCB on an extender card.

Follow this procedure or one similar to it to check the differential ARCNet signal:

1. Place the X-Ray Controller PCB on the extender card.
2. Connect the Workstation Interconnect Cable to the C-Arm.

3. Turn the system on and allow it to boot completely.
4. Connect channel 1 of a digital oscilloscope to ARCNET_HI, which is TP6 on the extender PCB.
5. Connect channel 2 of a digital oscilloscope to ARCNET_LO, which is TP7 on the extender PCB.
6. Configure the oscilloscope to sum the two components of the differential signal. This allows you to clearly observe the ones and zeroes.
7. Verify that all four nodes are present on the displayed ARCNet signal, and that these nodes are in proper sequence. You can identify them as follows:

   Node 1: Fluoro Functions PCB, hex code 40

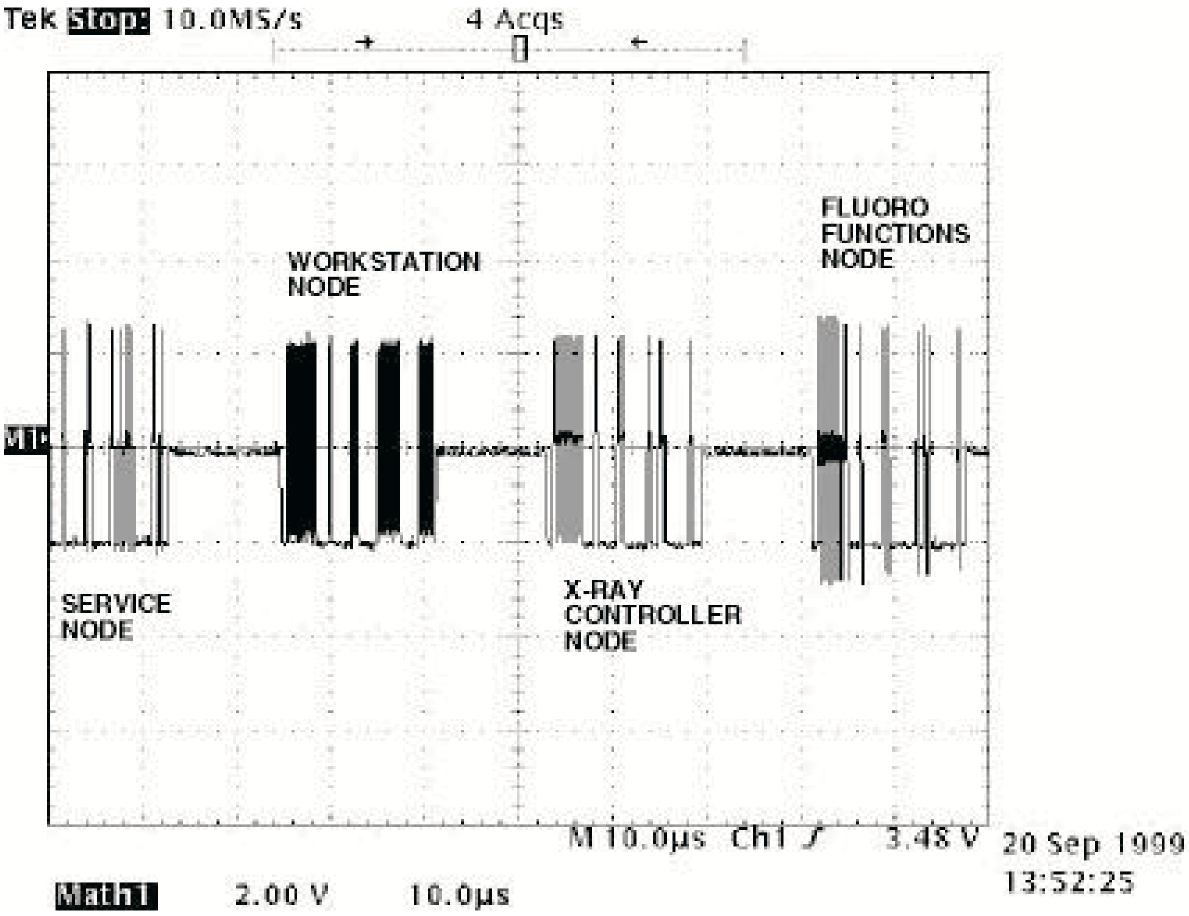
   Node 2: X-Ray Controller PCB, hex code 20

   Node 3: Service node, hex code 50

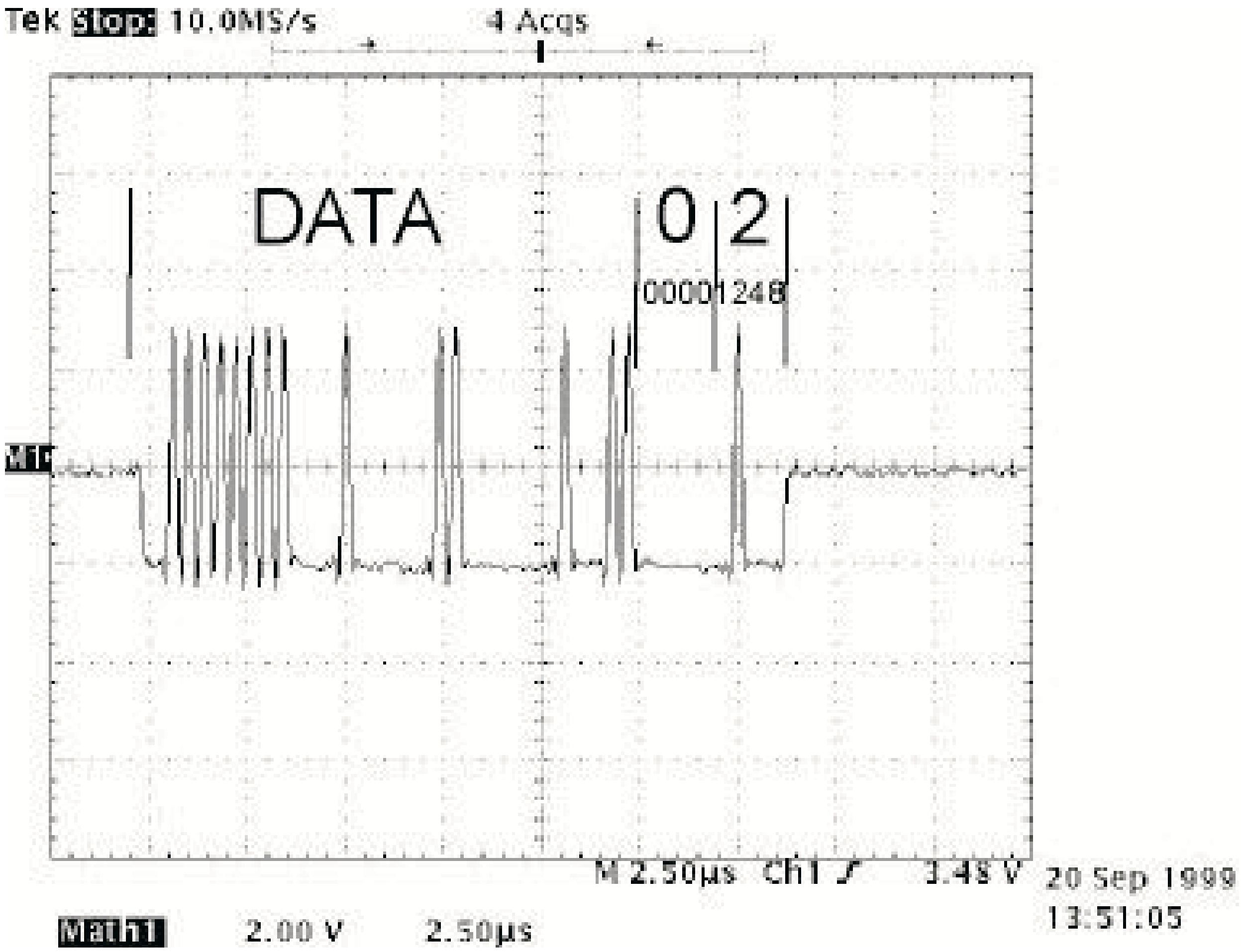
   Node 4: Workstation mode, hex code F0

The following illustration shows all four ARCNet nodes active. Investigate all inactive nodes.

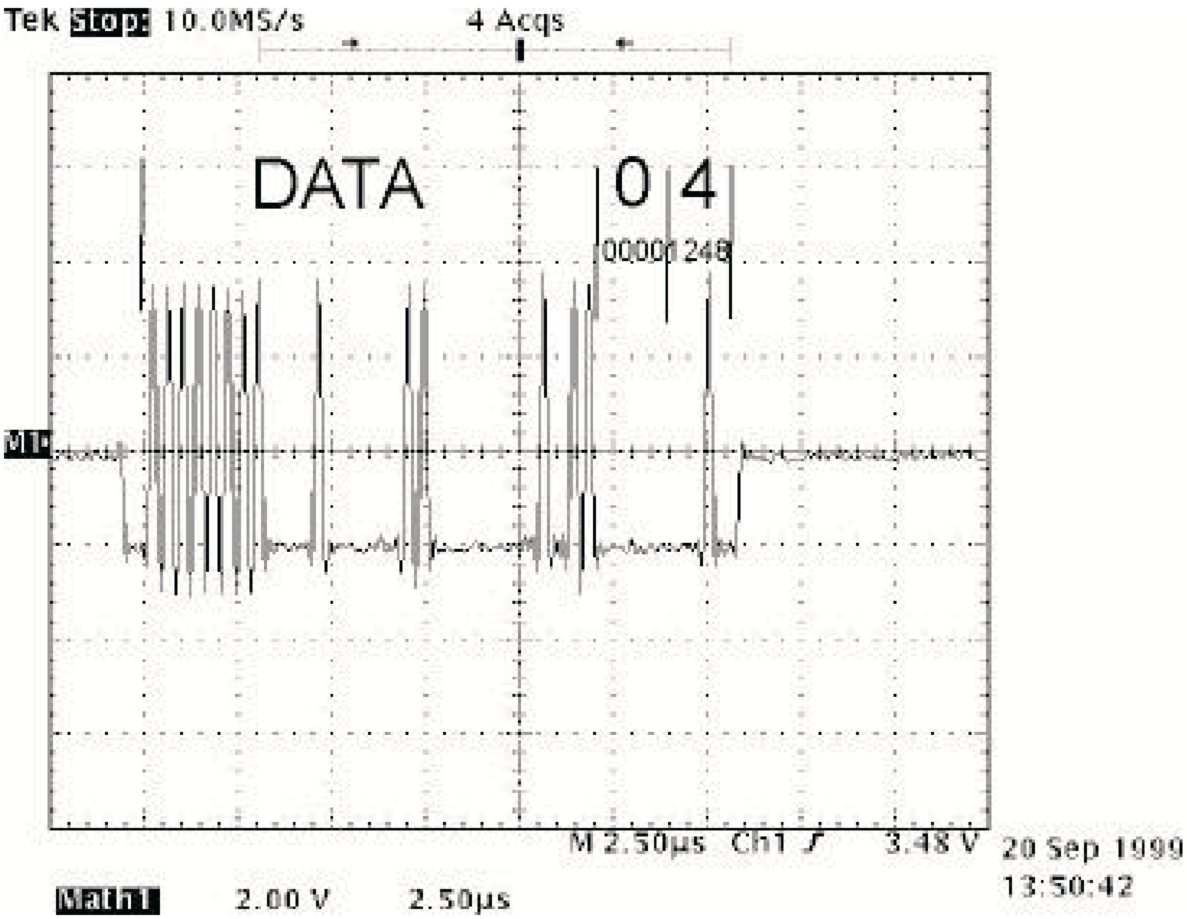
Subsequent illustrations show individual node details. Note that the scope sweeps right to left, displaying the most significant bit in the binary node identifier first. Printed node identification data was added, and was not generated by the oscilloscope.


Tek Stop: 10.0MS/s
4 Acqs
M1
WORKSTATION NODE
FLUORO FUNCTIONS NODE
SERVICE NODE
X-RAY CONTROLLER NODE
M 10.0µs Ch1 ∫ 3.48 V
20 Sep 1999
13:52:25
Math1 2.00 V 10.0µs

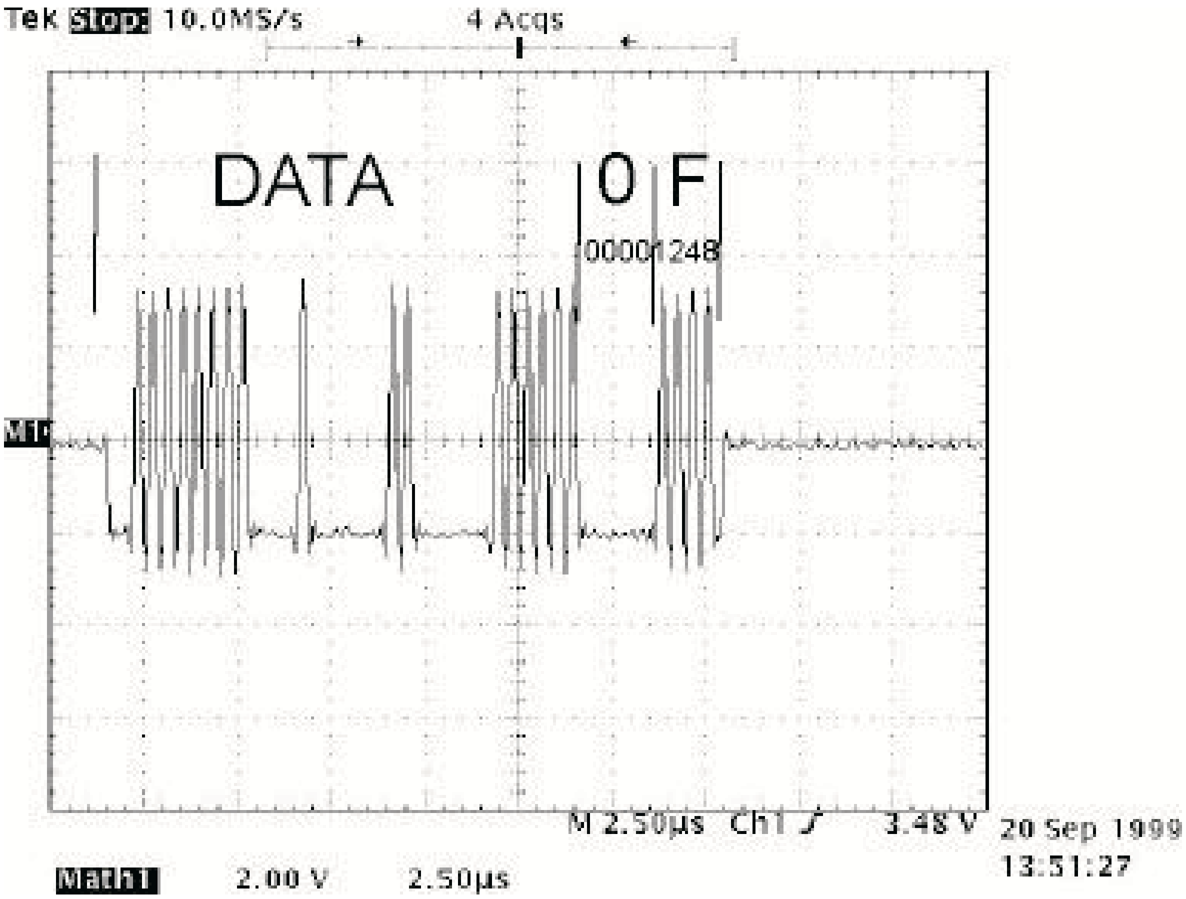
All ARCNet Nodes



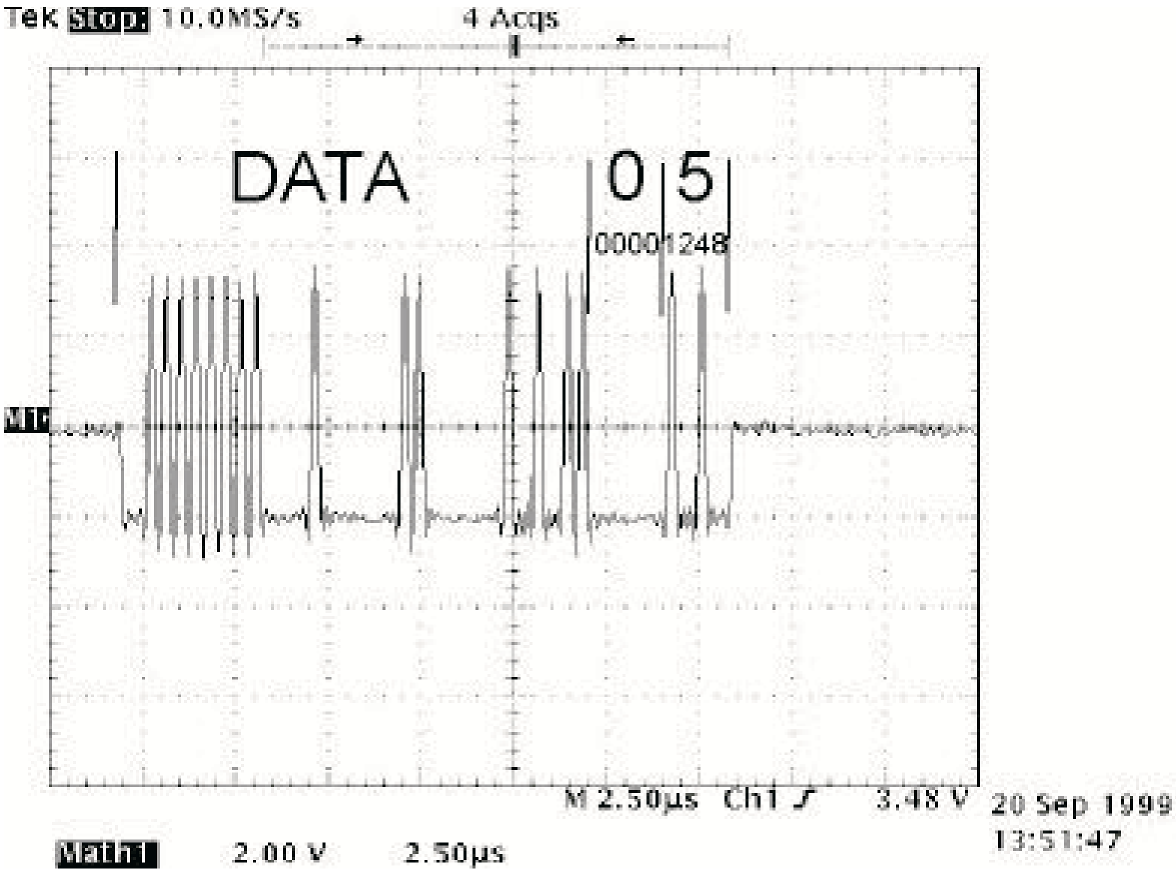
X-ray Controller Node


Tek Stop: 10.0MS/s
4 Acqs
DATA
0 4
00000 248
M1
M 2.50µs Ch1 ∫ 3.48 V
Math1 2.00 V 2.50µs
20 Sep 1999
13:50:42

Fluoro Functions Node



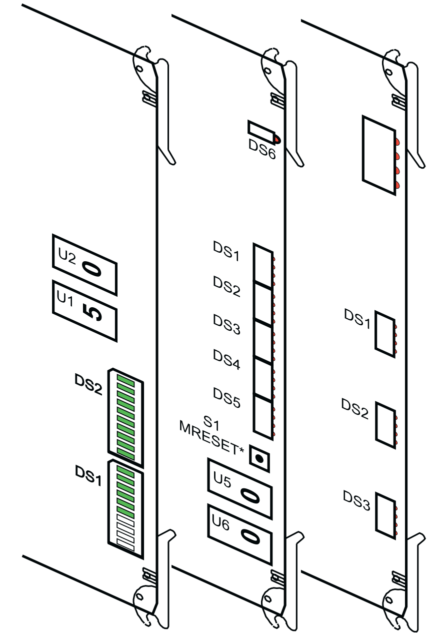
Workstation Node



Service Node

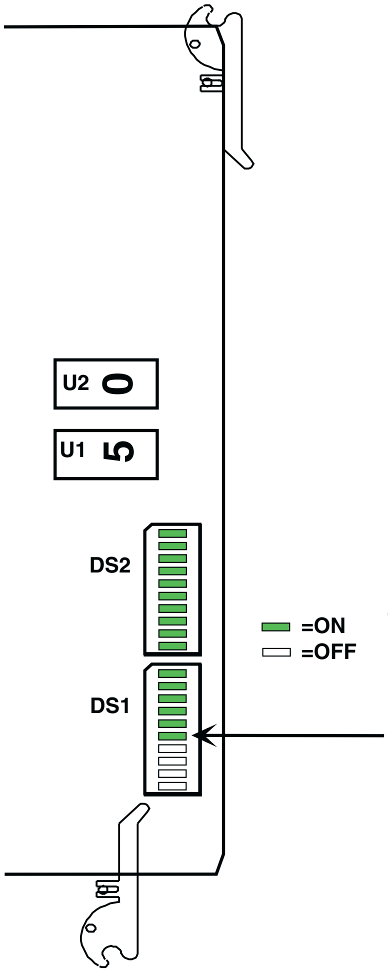
PCB Diagnostic LEDs

The following illustrations show LEDs on C-Arm PCBs that can be used for troubleshooting purposes. All of these PCBs reside in the C-Arm card rack. A simplified illustration of the location of these PCBs is shown next, followed by an illustration of the LEDs on each PCB. Some of the LEDs don't change state during system operation. Others turn on and off with normal system activity. Other LEDs come on only when the circuit they monitor is faulty. See the following illustrations for additional details.



Fluoro Functions PCB X-ray Contoller PCB HV Supply Regulator PCB

LED Locations on C-arm



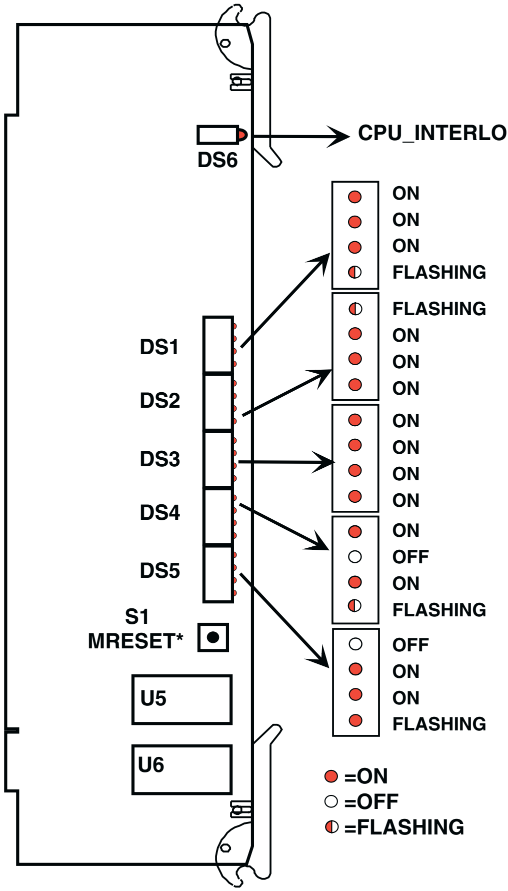
Events indicated by U1 and U2:

01 CPU registers initialized
02 Program flash memory checksum passed
03 Program initialized data area initialized
04 First program null data initialized
05 Secind program null data initialized
06 FFB application s/w started
07 FFB tasks initialized
08 FFB architecture s/w initialized
09 ArcNet initialized
10 Timers initialized

**The leds are shown as they appear after boot.
DS1 and DS2 are connected to the data bus.**

After bootup, segment 6 blinks on and off (1Hz.) to indicate that the microcontroller is running.

Fluoro Functions PCB LEDs

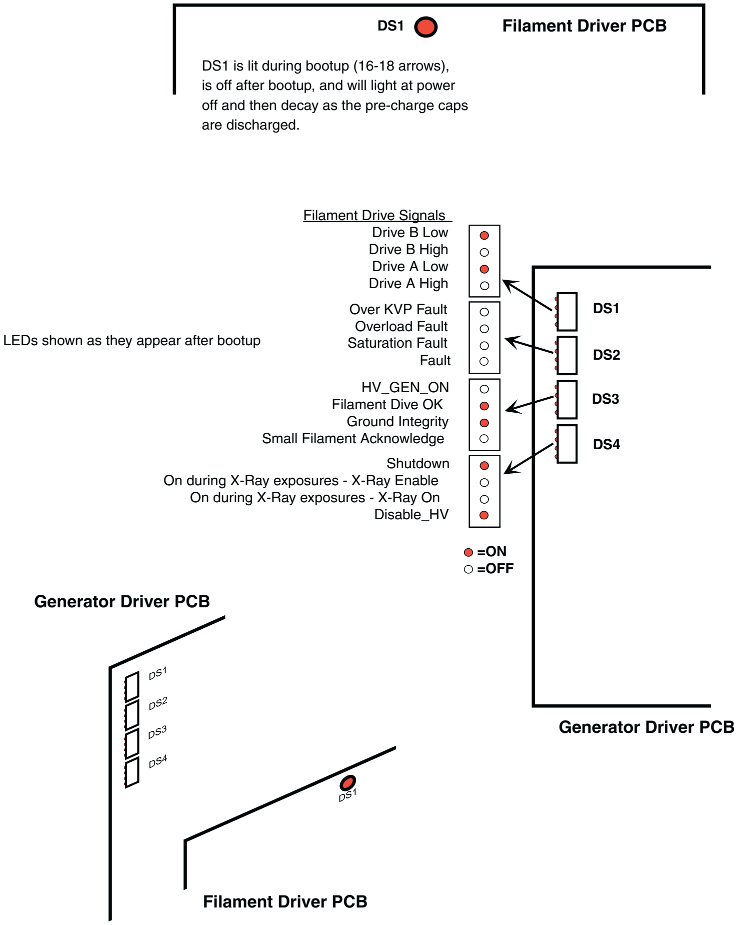

DS6
DS1
DS2
DS3
DS4
DS5
S1
MRESET*
U5
U6
ON
ON
ON
FLASHING
FLASHING
ON
ON
ON
ON
ON
ON
ON
ON
OFF
ON
FLASHING
OFF
ON
ON
FLASHING
● =ON
○ =OFF
◐ =FLASHING

CPU_INTERLOCK - Turns on at beginning of +24V interlock stage (13 arrows on display)

The LEDs are shown as they appear after boot

These LEDs are connected to the data bus and you should see activity during bootup. They were originally installed for software development purposes.

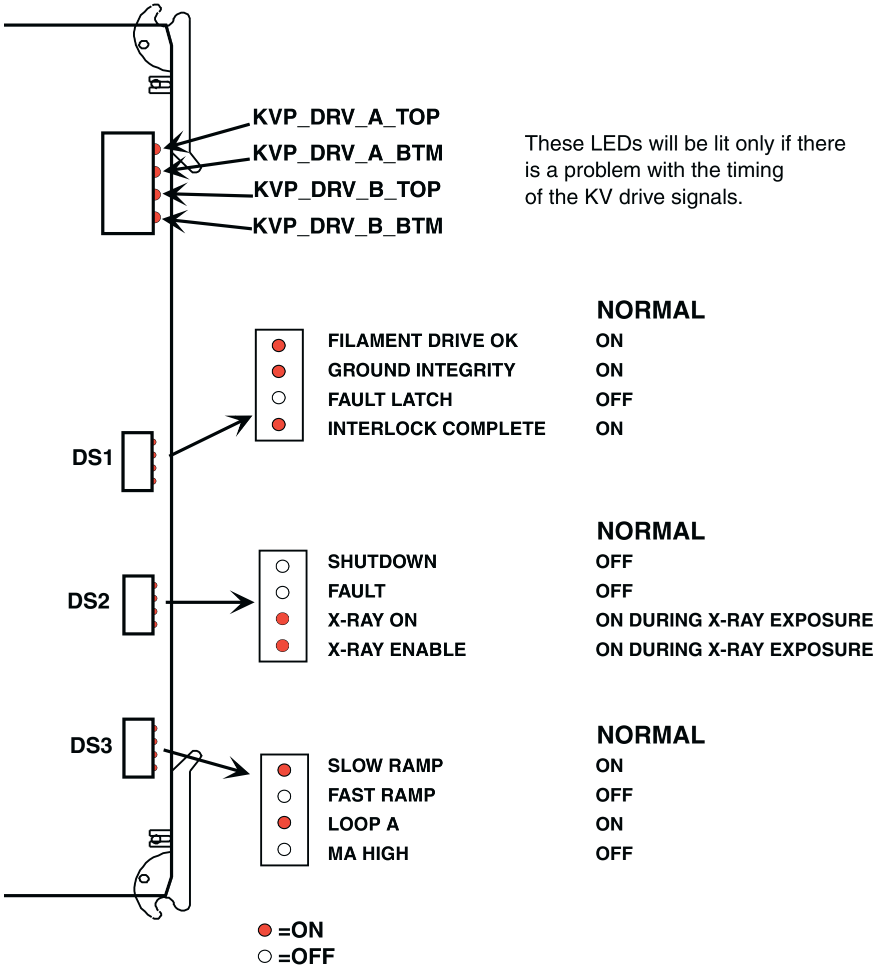
LEDs on X-ray Controller PCB


DS1
Filament Driver PCB
Filament Drive Signals
● Drive B Low
○ Drive B High
● Drive A Low
○ Drive A High
○ Over KVP Fault
○ Overload Fault
○ Saturation Fault
○ Fault
○ HV_GEN_ON
● Filament Dive OK
● Ground Integrity
○ Small Filament Acknowledge
● Shutdown
○ On during X-Ray exposures - X-Ray Enable
○ On during X-Ray exposures - X-Ray On
● Disable_HV
● =ON
○ =OFF
DS1
DS2
DS3
DS4
Generator Driver PCB
Generator Driver PCB
DS1
DS2
DS3
DS4
DS1
Filament Driver PCB

DS1 is lit during bootup (16-18 arrows), is off after bootup, and will light at power off and then decay as the pre-charge caps are discharged.

LEDs shown as they appear after bootup

LEDs on Generator Driver and Filament Driver PCBs


KVP_DRV_A_TOP
KVP_DRV_A_BTM
KVP_DRV_B_TOP
KVP_DRV_B_BTM
DS1
DS2
DS3

These LEDs will be lit only if there is a problem with the timing of the KV drive signals.

		NORMAL
●	FILAMENT DRIVE OK	ON
●	GROUND INTEGRITY	ON
○	FAULT LATCH	OFF
●	INTERLOCK COMPLETE	ON

		NORMAL
○	SHUTDOWN	OFF
○	FAULT	OFF
●	X-RAY ON	ON DURING X-RAY EXPOSURE
●	X-RAY ENABLE	ON DURING X-RAY EXPOSURE

		NORMAL
●	SLOW RAMP	ON
○	FAST RAMP	OFF
●	LOOP A	ON
○	MA HIGH	OFF

● =ON
○ =OFF

LEDs on High Voltage Supply Regulator PCB

HEX DISP	**FLUORO FUNCTIONS PCB SOFTWARE STATE**
01	Checking Flash
02	Initializing processor
03	Clearing Memory (BSS1)
04	Clearing Memory (BSS2)
05	OS initializing
06	Application Initialization beginning
07	Architecture utilities initializing
08	Network Initialization
09	Timers being initialized
0A	Tasks Initializing
FE	Fatal Error (System halted - Stack overflow, no memory, unhandled interrupt)
0D,FF	System halted (Out of Memory)
E0,XX,FF	ARCNET transmit pipe temporarily full
E4	Stack Memory dangerously low

The above table gives the codes output to the 2-digit Hexadecimal display on the Fluoro Functions PCB. 01-0A are sequential codes output board initialization. The remaining codes represent error conditions.

Calibration

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Light Sensor Calibration Using Rut 84

Overview

The Generator Calibration and Beam and Camera alignment procedures described next prepare the system for operation, and should be performed each time you replace a major system component. When possible, run these tests in the same sequence that they appear in this section.

Required Tools and Equipment

Extender PCB (00-879248)
Beam Alignment Fixture Tool (BAFT) (9-inch BAFT is 00-878105-01; 12-inch BAFT is 00-878867)
Boresite Alignment Tool (00-879599)
Converging line pair tool (00-900860)
Bristol six-flute spline tool, .048 (00-900920)
Wisconsin mesh tool (00-900040)
Serial cable (00-901559)
Three 1 mm sheets of copper (00-877682)
Remote Utility Tool (RUT) software (00-881671) (pre-OPIS)
Remote UtilitySuite software (00-884049)
AT keyboard (00-900598)
Nine-inch VGA monitor (00-901163)
Dosimeter with 15cc and 150cc Ion Chambers
DAP Paddle Holder (00-882027)
Tektronix Photometer
Fostec Calibrated Light Source
Fostec Light Source Control PCB (00-882068)

Power Supply Calibration

DC Power Supply PS1

Calibration of Power Supply PS1 consists of checking each output for proper voltage under load, and making adjustments to the high-current +5.1 Volt output, if necessary. Calibrate the supply when you replace it, and semiannually as described in the periodic maintenance procedures.

WARNING: *Dangerous AC voltages are present on connector J1 of Power Supply PS1 during the following calibration procedure.*

CAUTION: *Be careful when making the following measurements. Short circuiting a DC output can cause burns and equipment damage.*

Note: Make sure PS1 is fully installed with all loads connected before performing the following calibration procedure.

Calibrate DC Power Supply PS1 as follows:

1. Remove Left Side Cover.
2. Loosen and remove two torx screws and lockwashers that secure swing-out panel to left-hand side of generator chassis. Swing panel away from chassis to expose PS1.
3. Make sure Workstation's AC power plug is connected to facility AC outlet.
4. Turn Workstation on and allow system to boot.
5. Check output of high-current +5.1 Volt supply at J2-1. Output must measure 5.1 (+.1) Volts. If output is within range, go to step 7. If output needs adjustment, go to next step.
6. Adjust R51 until output measures 5.1 (+.1) Volts. If you can't adjust PS1 to produce a satisfactory 5.1 Volt output under normal load conditions (<8 Amps), replace PS1.

7. Check +12 Volt output at J2-8. Output should measure between +11.4 and +13.2 Volts. Output is not adjustable. Replace PS1 if output is not within this range under normal load conditions (<2.5 Amps).
8. Check -15 Volt output at J2-11. Output should measure between -14.55 and -15.45 Volts. Output is not adjustable. Replace PS1 if output is not within this range under normal load conditions (<1.2 Amps).
9. Check +15 Volt output at J2-4. Output should measure between +14.7 and 15.3 Volts. Output is not adjustable. Replace PS1 if output is not within this range under normal load conditions (<2.5 Amps).

Note: If one or more DC outputs do not meet specifications, replace PS1.

Multi-Output Power Supply PS2

Calibration of Power Supply PS2 consists of checking each output for proper voltage under load, and making adjustments when necessary. Calibrate the supply when you replace it, and semiannually as described in the periodic maintenance procedures

WARNING: *Dangerous AC voltages are present on connectors P1, P2, and P3 of Power Supply PS2 during the following calibration procedure.*

CAUTION: *Be careful when making the following measurements. Short circuiting a DC output can cause burns and equipment damage.*

Note: Make sure PS2 is fully installed with all loads connected before performing the following calibration procedure.

Calibrate DC Power Supply PS2 as follows:

1. Remove Left Side Cover.
2. Remove Component Tray Cover.
3. Make sure Workstation’s AC power plug is connected to facility’s AC outlet.
4. Turn Workstation on and allow system to boot.
5. Make sure that LEDs DS1, DS2, DS3, DS4, and DS5 are all lit.

6. Check the voltage between TP3 and TP1 (ground). If necessary, adjust trim pot R30 to give a reading of of +24.1 ±1%Volts.
7. Check the voltage between TP6 and TP1 (ground). If necessary, adjust trim pot R7 to give a reading of -6.10 Volts (+.25 Volts ±1%).
8. Check the voltage between TP5 and TP1 (ground). If necessary, adjust trim pot R31 to give a reading of +6.25 Volts ±1%.
9. Check the voltage between TP4 and TP1 (ground). It should measure +14.1 Volts ±10%.
10. Check the voltage between TP4 and TP2 (ground). It should measure –14.1 Volts ±1%.

Note: If one or more DC outputs do not meet specifications, replace PS2.

Generator Calibration

***WARNING**: The following procedures require you to take X-rays. Take appropriate precautions to protect yourself and others.*

***CAUTION**: The following procedure is critical to the safe operation of the C-Arm. Improper adjustment may cause premature failure of major system components.*

***CAUTION**: The following procedures require you to handle devices that are susceptible to damage from electrostatic discharge (ESD). Take appropriate measures to avoid equipment damage.*

High Voltage Supply Regulator (HVSR) Setup

1. Power down the Workstation and put the High Voltage Supply Regulator (HVSR) on an the extender PCB.
2. Power up the system and allow it to boot completely.

mA Null Adjustments

***Note**: When you boot the system for the first time after replacing the High Voltage Supply Regulator, the system may display* MA ON IN ERROR. *This is a fatal message that shuts the system down. This may happen because the mA Null adjustment described next needs to be done. The proper time to adjust the offsets is just after precharge completes because no kV control voltage is applied before precharge, and the mA readings from the sensors are not valid.*

***Note**: The system will display the MA ON IN ERROR message one more time after you perform the following adjustments. This is because software reads the sensors before they are correctly nulled.*

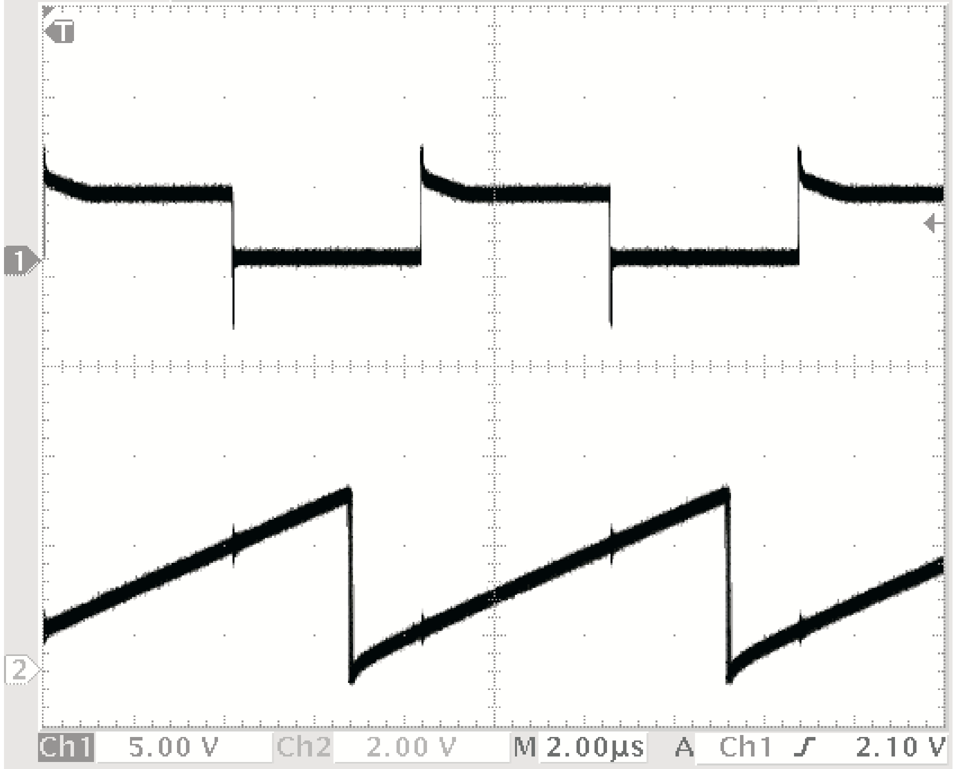
***Note**: It is critical that you adjust the voltages at TP39 and TP40 as closely as possible to 0.00 VDC. Any error greater than 5 millivolts is a failure that necessitates replacement of the High Voltage Supply Regulator PCB.*

1. Configure the C-Arm to provide 40 kVp @ .20 mA.
2. Connect a digital voltmeter between TP39 on the HVSR (LO_MA_SEN) and TP44 (LO_MA_ SEN_REF).
3. Adjust R138 for 0.00 VDC ± 1.5 millivolts.
4. Connect the digital voltmeter between TP40 (HI_MA_SEN) and TP49 (HI_MA_SEN_REF).
5. Adjust R126 for 0.00 VDC ± 1.5 millivolts.

PWM Chip Sync Adjustment

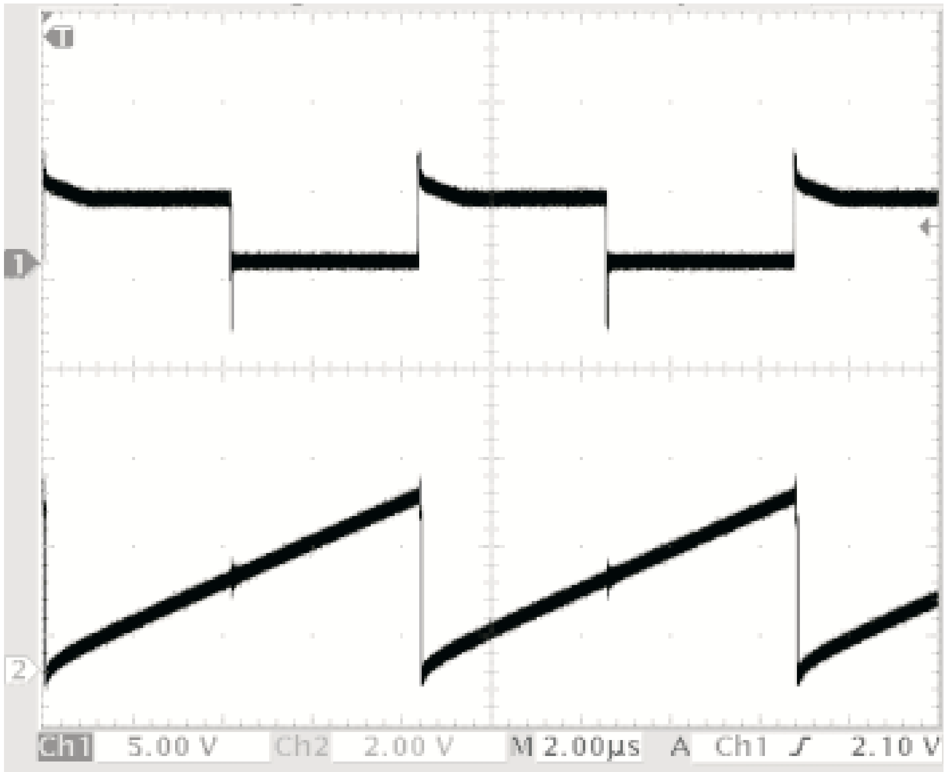
***CAUTION**: Do not make an X-ray exposure at this point in the procedure.*

1. Connect channel 1 of the oscilloscope to TP79 (HF_SYNC) and channel 2 to TP57 (RAMP). Trigger the oscilloscope on channel 1.
2. Adjust R139 clockwise until the two signals come out of sync with each other as shown in the next illustration. Note the position of the pot.



HF_SYNC and RAMP Signals Out of Sync

3. Adjust R139 counterclockwise until the two signals come out of sync again. Note the position of the pot.
4. Set R139 midway between the two out-of-sync points. Verify that both signals are synchronized with R139 in this position.

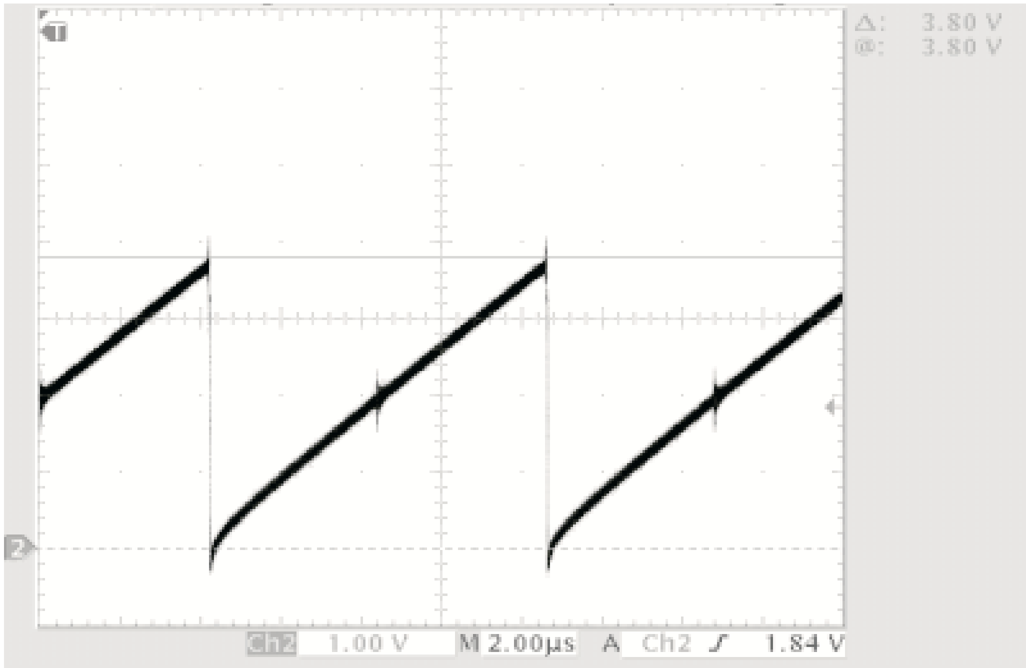

T
1
2
Ch1 5.00 V
Ch2 2.00 V
M 2.00µs
A Ch1 ∫ 2.10 V

HF_SYNC and RAMP Signals In Sync

Ramp Peak Voltage Adjustment

***CAUTION**:* *Do not make an X-ray exposure at this point in the procedure.*

While viewing channel 2 of the oscilloscope (TP57 RAMP), adjust R109 for a peak amplitude of 3.8 Volts. The following figure shows the RAMP signal after proper adjustment.



Properly Adjusted Ramp Peak Voltage

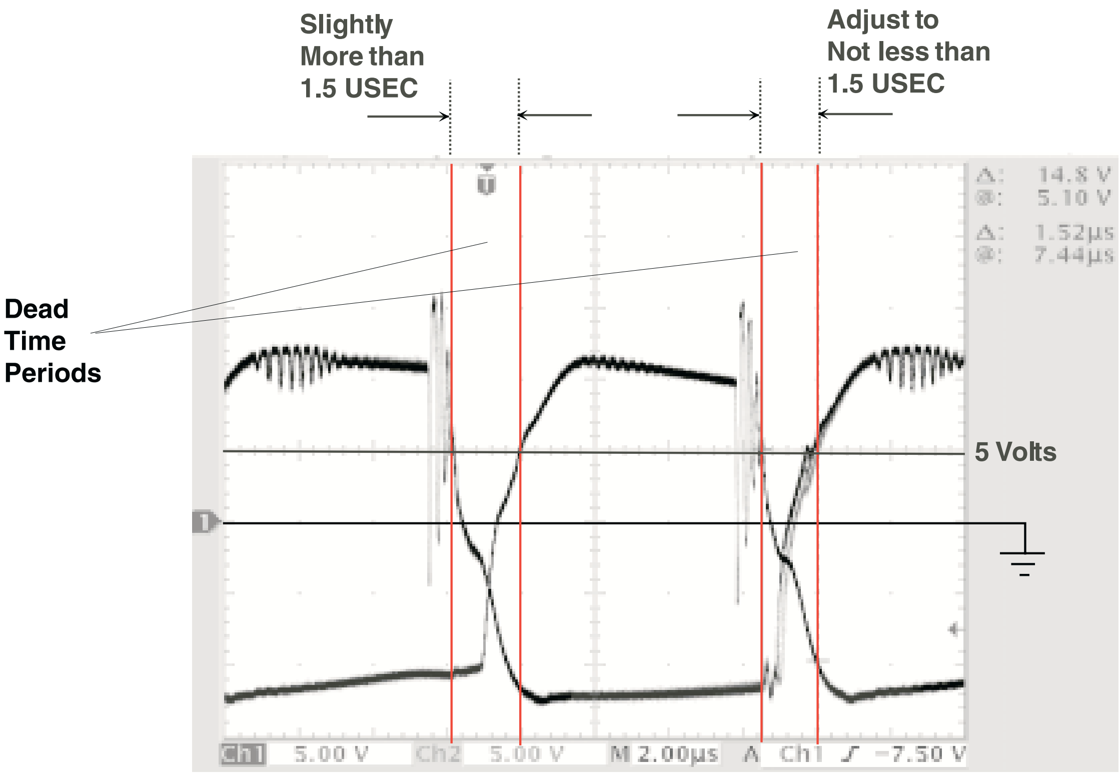
Adjustment of Dead Time Between kV Drive Signals

***CAUTION**:* *To prevent cross-conduction in and destruction of the IGBTs, turn both R137 and R84 on the High Voltage Supply Regulator PCB fully clockwise. This increases the dead time between High Voltage drive pulses to maximum.*

***CAUTION**:* *This adjustment sets up the dead time between the kV drives signals on each of the IGBT pairs (Q1 and Q2). Misadjusting the dead time so that both transistors of Q1 or Q2 are on at the same time damages the transistors.*

***Note**:* *Variations between Generator Driver PCBs can cause dead time adjustments to vary. Check the dead time adjustment any time you change the Generator Driver PCB.*

1. Turn system off.
2. Connect channel 1 of the oscilloscope to TP67 on the Generator Driver PCB and oscilloscope channel 2 to TP68.
3. Turn system on and allow Workstation and C-Arm to boot completely.
4. Select a technique of 40 kVp @ 0.2 mA.
5. Align the two channels on the oscilloscope so that they have the same reference point, and adjust for about 5 Volts per division vertical sensitivity.
6. While observing the dead time (the time when both pulses are below the 5 VDC reference), take an X-ray, and adjust R137 on the High Voltage Supply Regulator PCB counterclockwise to achieve a dead time of about 1.5 µsec on the drive waveforms at the 5 VDC level. Typically one dead time will be longer than the other. Make sure the **smaller** of the two is as close to 1.5 µsec as possible without getting any lower than that. Refer to the following illustration, which shows the kV drive signals with the dead time properly adjusted.



Slightly More than 1.5 USEC

Adjust to Not less than 1.5 USEC

Dead Time Periods

5 Volts

Correctly Adjusted kV Drive Signals

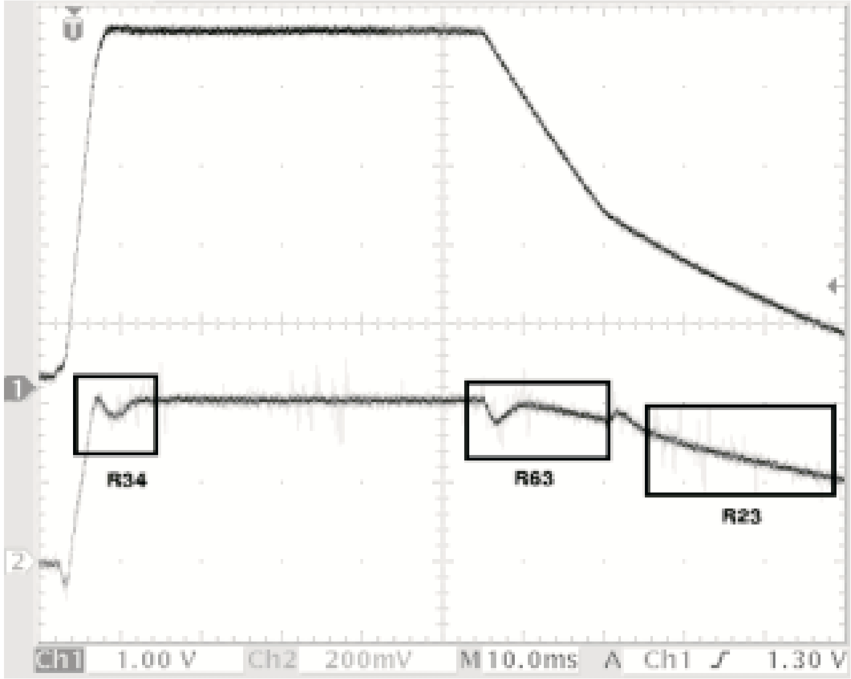
***CAUTION**:* *The dead time is not the same on both sides of the drive pulses. Find the dead time that is **smallest**, and adjust it for 1.5 microseconds. Failure to do this may cause the dead time on one side of the drive pulses to be too short, and damage the IGBTs.*

CAUTION: *There may be some apparent drive signal instability during dead time adjustment. Make sure that the dead time does not become less than 1 microsecond during these unstable periods. Failure to observe this precaution may damage the IGBTs.*

7. Connect the oscilloscope to TP66 and TP70 on the Generator Driver PCB, and repeat steps 2 and 3 for the B dead time adjustment. Use R84 on the High Voltage Supply Regulator PCB.

Differentiator Setup

1. Move channel 1 of the oscilloscope to TP21 (KV_SEN_TP) on the HVSR. Connect channel 2 to TP39 (LO_MA_SEN).
2. On the Workstation, select 4 pps and a technique of 70 kVp @ 1 mA.
3. Adjust the three parts of the LO_MA_SEN waveform so that it looks like the waveform in the following illustration. Adjust R63 first, followed by R23 and then R34.



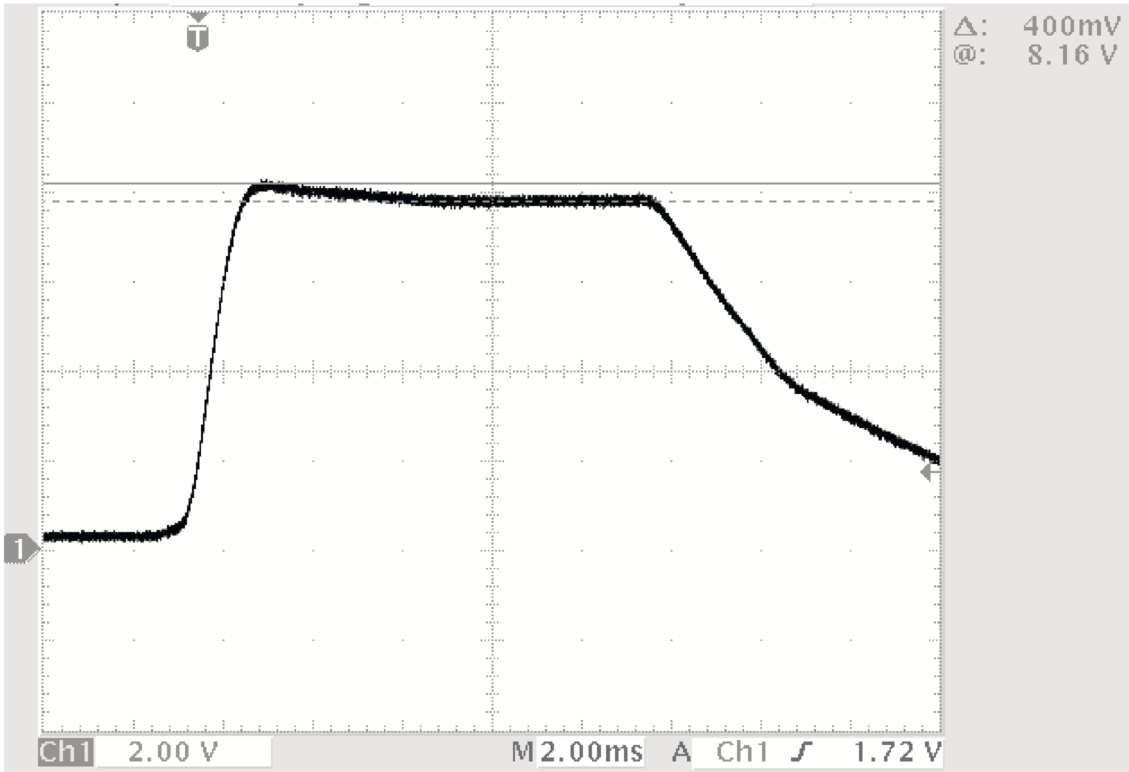
Properly Adjusted Differentiator Waveforms

Note: *R63 moves the sloping portion of the form between the dip at left and the hump at right, up and down. R23 moves the trailing slope up and down to the right of the hump. The object is to get a smooth curve, ignoring the dip and hump. Adjust R34 to give a rise time with a small dip at the beginning of the ramp, and the peak of the ramp not higher than the flat portion.*

Stability Pot (R83) Overshoot Adjustment

***CAUTION**:* *Failure to perform this adjustment may cause kV overshoots and X-ray tube arcing.*

1. If you are installing a new HVSR PCB, turn R83 on the High Voltage Supply Regulator PCB fully clockwise (10 turns max), and then turn it counterclockwise about one turn. This provides an approximate starting adjustment. Otherwise, skip this step.
2. Connect channel 1 of the oscilloscope to TP21 (KV_SEN_TP) on the High Voltage Supply Regulator PCB and channel 2 to TP40 (HI_MA_SEN).
3. Select 15 or 30 fps and 15 or 30 pps on the Workstation. While taking an HLF X-ray, set the kVp for 40 and adjust mA to 11. Observe the kVp signal at TP21 (KV_SEN_TP) looking for kVp overshoot on the leading edge of the kVp waveform. If kVp overshoot exceeds 400 mV, adjust R83 to reduce it. Repeat this procedure, increasing the kVp by 10 each time until you reach 120 kVp.
4. While observing the oscilloscope, adjust R83 for about 400 mV of overshoot--This represents about a 5% overshoot. See waveform in following illustration.



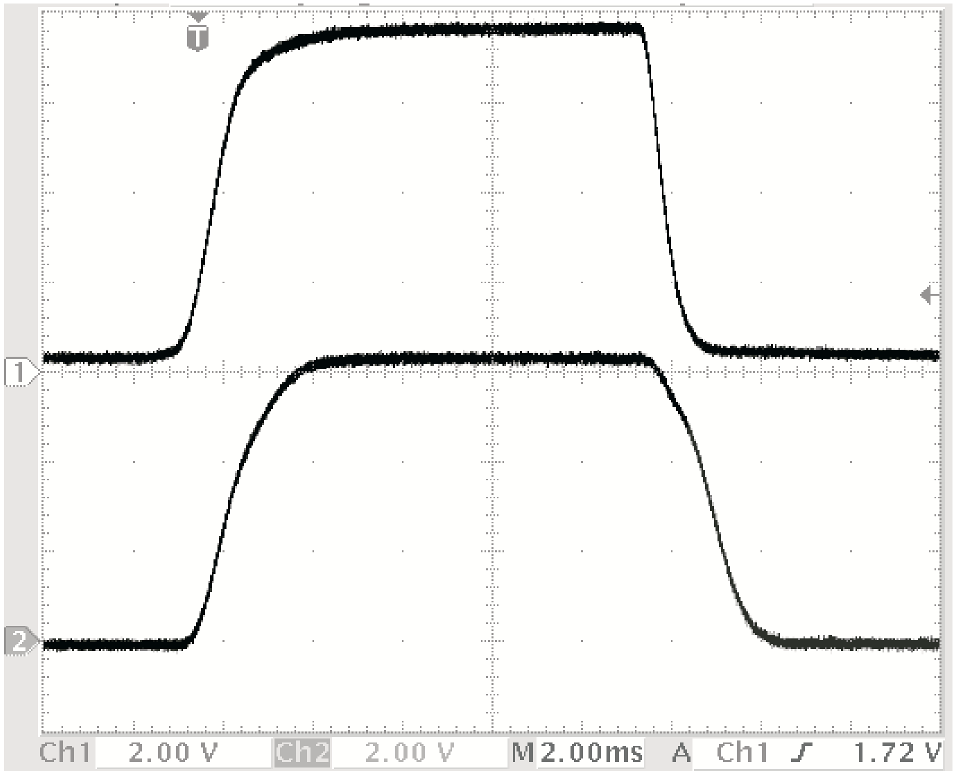
400 mV Overshoot Adjustment

5. Re-check mA offset adjustments before doing filament calibration.

Note: Before you perform the next step, the Filament calibration must be done.

6. Select a technique of 100 kV @ 100 mA. Monitor TP21 (KV_SEN_TP) on one oscilloscope channel, and monitor TP40 (HI_MA_SEN) on the other oscilloscope channel, using TP49 (HI_MA_SEN_REF) for ground. The two waveforms you see should appear as follows. (The top trace is kV and the bottom trace is HI_MA_SEN.)

7. Repeat the previous step with 120 kV @ 125 mA.



KV_SEN_TP and HI_MA_SEN Waveforms

Filament/Duty Cycle Calibration

Note: For pre-OPIS system software, use the RUT utility CD.

Using RUT

1. Attach the Serial Com Port of the Laptop to the ARCNET Connection (J4) of the Workstation. On the Laptop, launch RUT.
2. In the upper left hand corner of the Main Menu Window click on *Tools.* Then highlight and click on *Connect.*
3. When the *Login Succeeded* Message comes up point and click on the OK Button.
4. In the left-hand column, click on *Filament Calibration.* When the Upload and Save Window appears, point and click on NO .
5. When the Filament Calibration Window appears, click on Take Duty Cycle Data.
6. When the Exposure Warning Window appears, click on OK.
7. When the new window appears, hold down X-Ray on switch on the Mainframe or hold down the Fluoro Switch on the Foot Pedal (with a weight of some kind), then click OK . At that time you will notice that on the Control Panel of the Mainframe, Running Calibration is being displayed.

Note: The Filament Calibration takes about 12 minutes to complete.

8. Verify that the Filament Calibration was completed without any failures. Release the X-Ray switch on the Mainframe or the Foot Pedal to stop making x-rays.
9. Click on *File* located in the upper left-hand corner.
10. Highlight and click Save Duty Cycle Data File As.
11. When the new window appears, type in XXXXXXXX.dcd (Mainframe’s Barcode Number) then click on Save. Verify Duty Cycle Data File was saved.
12. Click on Interpolate Data. Verify Interpolation is done.
13. Click on *File* located in the upper left-hand corner.

14. Highlight and click on Save Filament Calibration Data File As.
15. When the new window appears, type in XXXXXXXX.fcl (Mainframe's Barcode Number) then click on *Save.* Verify Calibration Data File was saved.
16. Click on *File* located in the upper left-hand corner.
17. In the new window that appeared, highlight and click on *Download Filament Calibration Data To 9800.*
18. Verify that the Filament Calibration Data File was downloaded to the 9800, by checking for the Download Complete in the lower right hand corner of the RUT window.

Using UtilitySuite

1. Attach the Serial Com Port of the Laptop to the ARCNET Connection (J4) of the Workstation. On the Laptop, point and double click on the tool Icon and go to RUT.
2. In Main Menu Window click on *Connect*->System.
3. In the left-hand column, click on *Filament Calibration.*
4. When the Filament Calibration Window appears, click on Take Duty Cycle Data.
5. Follow the prompt to complete the data collection.

Note: The Filament Calibration takes about 12 minutes to complete.

6. Verify that the Filament Calibration was completed without any failures. Release the X-Ray switch on the Mainframe or the Foot Pedal to stop making x-rays.

7 Click on Interpolate Data. Verify Interpolation is done.

8. Click on *File->Save As->Generator File*.
9. When the new window appears, type in XXXXXXXX (Mainframe's Barcode Number) then click on *Save.* Verify the file was saved.
10. Click on *File->Save->To System->Generator*.
11. Re-boot the system.

Fluorographic Pulsed mA Accuracy Test

1. Power up the Workstation and allow the Workstation and C-Arm to boot completely.
2. Use the oscilloscope to monitor TP40 (HI_MA_SENSE) on the HVSR PCB. You will be converting voltages displayed on the scope to tube current values:
   A. TP40 to ground: 51.6 mV = 1mA
   B. TP40 to TP49: 50 mV = 1 mA)
3. Use a second channel on the oscilloscope to monitor TP21 (KVP_SENSE_TP) on the HVSR. You will be converting voltages displayed on the scope to kVp values (1 VDC = 15 kVp).
4. Press the **PULSE** button on either C-Arm control panel to enable the Pulse mode. Select 15 pps.
5. Set the C-Arm to 60 kVP @ 40 mA. Step on the HLF foot pedal to make a pulsed HLF exposure. Record the peak amplitude of the pulses you see on TP40. Verify that the result is 40 mA ± 4 mA (1.85 to 2.25 VDC).
6. Step on the HLF foot pedal to make another pulsed HLF exposure. Record the peak amplitude of the pulses you see on TP21. Verify that the result is 60 kVp ±4 kVp (3.67 to 4.29 VDC).
7. Set the C-Arm to 90 kVp @ 40 mA. Step on the HLF foot pedal to make a pulsed HLF exposure. Record the peak amplitude of the pulses you see on TP40. Verify that the result is 40 mA ± 4 mA (1.85 to 2.25 VDC).
8. Step on the HLF foot pedal to make another pulsed HLF exposure. Record the peak amplitude of the pulses you see on TP21. Verify that the result is 90 kVp ± 4 kVp (5.63 to 6.16 VDC).
9. Set the C-Arm to 120 kVp @ 35 mA. Step on the HLF foot pedal to make a pulsed HLF exposure. Record the peak amplitude of the pulses you see on TP40. Verify that the result is 35 mA ± 4 mA (1.59 to 1.99 VDC).
10. Step on the HLF foot pedal to make another pulsed HLF exposure. Record the peak amplitude of the pulses you see on TP21. Verify that the result is 120 kVp ± 4 kVp (7.60 to 8.12 VDC).
11. Power down the Workstation and take the High Voltage Supply Regulator off the extender. Install the HVSR PCB back in the C-Arm chassis.

Entrance Exposure Rate Limits Verification

1. Install Collimator cover over the Collimator assembly.
2. Position the 15cc Dosimeter Ion Chamber 30 cm above the Image Intensifier input grid. (Measure from the grid surface to the center of the Ion Chamber.)
3. Measure the current atmospheric pressure in mm of mercury.
4. Measure the current room temperature in °C.
5. Enter the temperature and pressure into the Dosimeter (if applicable).

Enter mA Limit Values Using RUT

CAUTION: The following test must be done without overheating the tube anode. Keep your exposures as short as possible. If ANODE WARM message appears, wait before making the next test.

Note: For pre-OPIS system software, use the RUT utility CD.

1. Launch RUT, proceed as follows:
    a. In the upper left-hand corner, click on ***Tools.***
    b. In the window that appears, highlight and click on ***Connect.*** When the Login Succeeded Window appears, click OK.
    c. In the Left-hand Window, click on ***Ma Limit Editor.*** When the UPLOAD and SAVE Window appears, point and click on No.
2. When the *mA Limit File Editor* window appears, select Fluoro mode.
3. Select Manual Fluoro mode and Normal magnification. Select 40 kVp @ 10 mA. During a fluoro exposure, increase kVp until the Dosimeter reading is close to but not over the maximum corrected exposure rate of 9.26 R/minute. This is the breakpoint.

4. Record the breakpoint at the corresponding kVp listing in the mA Limit File Editor Window.
5. Increase kVp to the next setting that is evenly divisible by 5 (in this case, 90 kVp). Reduce mA until the entrance exposure rate does not exceed 9.26 R/minute. In the mA Limit File Editor, record the mA value by the corresponding kVp entry.
6. Repeat and record measurements, increasing kVp by five kVp each time, for the remaining kVp settings.
7. Once you have finished filling in mA values from the breakpoint, click *Interpolate*.
8. When the Least Squares Polynomial Window appears click OK.
9. In the *mA Limit File Editor* window, change the mode from *Fluoro to HLF.*
10. Select Manual Fluoro mode and Normal magnification. Select 40 kVp @ 20 mA. During an HLF Fluoro exposure, increase kVp until the Dosimeter reading is close to but not over the maximum corrected exposure rate of 18 R/minute. This is the breakpoint.

***Note**: 18.0 R/minute is maximum exposure rate of 20 R/minute minus 10 % (5% for setup errors and 5% for dosimeter errors).*

11. Record the breakpoint at the corresponding kVp listing in the *mA Limit File Editor* window. For example, if you reached 18.0 R/minute at 85 kVp, enter 10 mA by 85kVp .
12. Increase kVp to the next setting that is evenly divisible by 5 (in this case, 90 kVp). Reduce mA until the entrance exposure rate does not exceed 18.0 R/minute. In the *mA Limit File Editor*, record the safe mA value by the corresponding kVp entry.
13. Repeat measurements, increasing kVp by five kVp each time, for the remaining kVp settings.
14. Once you have finished filling in mA values from the breakpoint, click *Interpolate*.
15. When the *Least Squares Polynomial* window appears, click *OK*.
16. Click on ***File*** located in the upper left-hand corner.
17. Highlight and click on ***Save Ma Limit File As.***
18. When the new window appears, the barcode should appear in the file name (if not, type it in) XXXXXXXX.mal (Mainframe's Barcode Number) then click on SAVE. Verify the File was saved.
19. Click on ***File*** located in the upper left-hand corner.

20. In the new window that appeared, highlight and click on ***Download Ma Limit Data To 9800 .*** Verify that the mA Limit File was downloaded to the 9800.

Note: The Mainframe will display Please Wait on the Control Panel while the files are being downloaded to the Mainframe. When downloading is completed the Mainframe's displays will return to normal.

Enter mA Limit Values Using UtilitySuite

1. In the upper left-hand corner, click on ***Tools.***
2. In the Left-hand Window, click on ***mA Limit Editor.*** 4. When the mA Limit File Editor Window appears select Fluoro Mode.
3. Select Manual Fluoro mode and Normal Mag. Select 40 kVp @ 10 mA. During a Fluoro exposure, increase the kVp until the Dosimeter reading is close to, without going over, the maximum corrected exposure rate of 9.26 R/minute. This is the breakpoint.
4. Record the breakpoint at the corresponding kVp listing in the mA Limit File Editor Window.
5. Increase kVp to the next nearest setting that is evenly divisible by 5 kVp. Decrease mA to prevent the exposure rate from exceeding 9.26 R/minute. Record the mA value in the mA Limit File Editor (at the corresponding kVp).
6. Repeat and record measurements, increasing kVp by five each time, for remaining kVp settings.
7. Once all of the 5 kVp increments are filled in from the start of the Breakpoint, click on the Interpolate Button.
8. In the mA Limit File Editor Window change the mode from Fluoro to HLF.
9. Select Manual Fluoro mode and Normal Mag. Select 40 kVp @ 20 mA. During a BOOST Fluoro exposure, increase the kVp until the Dosimeter reading is close to, without going over, the maximum corrected exposure rate of 18 R/minute. This is the breakpoint.

Note: 18.0 R/min is the maximum exposure rate of 20 R/min reduced by 10% (5% tolerance in setup values and 5% tolerance of dosimeter.)

10. Record the breakpoint at the corresponding kVp listing in the mA Limit File Editor Window. Example, at 85 kVp you would enter 20 mA.

11. Increase kVp to the next nearest setting that is evenly divisible by 5 kVp. Decrease mA to prevent the exposure rate from exceeding 18 R/minute. Record in the mA Limit File Editor at the corresponding kVp the mA value.
12. Repeat and record measurements, increasing kVp by five each time, for remaining kVp settings.
13. Once all of the 5 kVp increments are filled in from the start of the Breakpoint, click on the Interpolate Button.
14. When the Least Squares Polynomial Window appears click OK.
15. Click on ***File*** ->***Save As-> Generator File.*** .
16. When the new window appears, the barcode should appear in the file name (if not, type it in) XXXXXXXX.mal (Mainframe's Barcode Number) then click on SAVE. Verify the File was saved.
17. Click on ***File->Save->To System->Generator***.

Note: The Mainframe will display Please Wait on the Control Panel while the files are being downloaded to the Mainframe. When downloading is completed the Mainframe's displays will return to normal.

Verify mA Limit Values and Maximum HLF

1. Make a 120 kVp manual HLF exposure. Verify the reading is 18.0 ±0.5 R/minute.
2. During a Fluoro exposure, increase kVp and verify that mA begins to decrease at the maximum corrected exposure rate.
3. Verify that the Dosimeter reading does not exceed the maximum corrected exposure rate of 9.26 R/minute throughout the kVp range.

Note: It may be necessary to use the mA Limit File Editor to readjust the mA values.

4. Click *File* in the *mA Limit File Editor* screen.
5. Highlight and click on *Save mA Limit File As.*
6. When the new window appears, type in XXXXXXXX.mal. (XXXXXXXX is the C-Arm serial number). Click *Save* and verify that RUT saves the mA Limit file.
7. Click *File* again.

8. When the new window appears, highlight and click on *Download mA Limit Data to 9800*.

Note: The C-Arm control panel displays PLEASE WAIT while files download to the Workstation. When downloading is complete, the control panel displays return to normal.

9. Click *Tools* and *Disconnect* to disconnect RUT.
10. Reboot the system and verify that it limits mA to the correct values for Fluoro and HLF.

Dose Area Product Calibration Using RUT

Note: For pre-OPIS system software, use the RUT version of your utility CD.

For **Dual-leaf Collimators**, do steps 1 through 21 and 96 (N/A 22-96). You may use either a Kiethley or a Radcal dosimeter.

For **Single-leaf Collimators**, do steps 1 through 96, using a Kiethley dosimeter **only**.

Note: In order to activate the X key toggle, hold down the CTRL + ALT + M keys. Then, the X key on the DOS keyboard will toggle DAP On and Off.

*Note: The **DOS keyboard** is the peripheral keyboard connected to the Workstation, typically used in conjunction with the small monochrome monitor.*

1. Position the 150/180cc dosimeter ion chamber in the center of the Image Intensifier. See the instructions just above about which brand dosimeter may be used.
2. On the Generator’s Control Panel, select Manual Fluoro Mode and open the Collimator and Iris Leafs completely.
3. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter and Iris reports are ≤1.
4. On the DOS Keyboard press the X Key.
5. In the left hand side of the RUT Main Menu, click on Dose Area Product Calibration in the left window. When the DAP Information Message appears, click on OK.

6. At the top of the Dap Calibration Window, ensure that the proper Image Intensifier Size, and the proper number of Collimator Leafs, for the system under test, are set.
7. Manually adjust the technique to 40 kVp and 5 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
8. Divide the Dose Rate you recorded in step 7 by 5 and enter the number into the corresponding KVp Field in the DAP Calibration Window. Record the Dose Rate in mR/second.
9. Manually adjust the technique to 50 kVp and 5 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
10. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
11. Manually adjust the technique to 60 kVp and 4 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
12. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
13. Manually adjust the technique to 80 kVp and 3 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
14. Divide the Dose Rate you recorded in step 13 by 3 and enter the number into the corresponding KVp Field in the DAP Calibration Window. Record the Dose Rate in mR/second.
15. Manually adjust the technique to 100 kVp and 2 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
16. Divide the Dose Rate you recorded in step 15 by 2 and enter the number into the corresponding KVp Field in the DAP Calibration Window. Record the Dose Rate in mR/second.
17. Manually adjust the technique to 120 kVp and 2 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
18. Divide the Dose Rate you recorded in step 17 by 2 and enter the number into the corresponding KVp Field in the DAP Calibration Window. Record the Dose Rate in mR/second.
19. Point and click on the Calculate Coefficients Button.
20. In the upper left-hand corner of the RUT Main Menu, point and click on FILE .

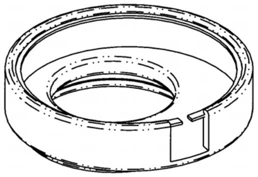
21. Point, highlight and click on Save As Dap Calibration File. In the Save Configuration As Window, ensure that the Generator's Barcode followed by file extension.dap is displayed in the FILE NAME Box. Then point and click on the SAVE Button.

For dual-leaf collimators only: skip steps 22-95, do step 96.

For single-leaf collimators only: complete this Section up to this point, then continue with steps 22 - 96.

Note: During this portion of the DAP Calibration, if the Collimator Iris, Leaf, or Rotation does not drive to the specified report number (plus or minus), simply adjust it into the correct range using the manual controls on the Mainframe's Control Panel. The utility's job is just to get the parameter in the ball-park for the convenience of the technician.

22. Install the DAP Fixture Tool (P/N 00-882027-01), with the Kiethley 150 cc ion chamber inserted in it, onto the collimator cover.



DAP Fixture Tool

23. On the Generator's Control Panel, manually close the Collimator Leaf completely.
24. On the Generator's Control Panel, set the technique to 80 kVp and 3 mA. Manually adjust the Collimator Rotation fully ↺ CCW, **then fully open the iris manually.**
25. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **185**

    For 12-inch System **60**

    Point and click on the Drive Iris To Button.
26. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is ≤ 2

    For 12-inch Systems, the Iris report is ≤ 2

27. On the DOS Keyboard, press the X Key.
28. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
29. Manually adjust the Collimator Rotation to 180 ± 2.
30. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is ≤2

    For 12-inch Systems, the Iris report is ≤ 2
31. On the DOS Keyboard, press the X Key.
32. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
33. In the Dose Area Product Calibration Window, in the box provided next to the Drive Iris To Button, click on the box containing the following iris position:

    For 9-inch System **250**

    For 12-inch System **130**

    Point and click on the DRIVE IRIS TO Button.
34. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2

    For 9-inch Systems, the Iris report is 17 ± 2

    For 12-inch Systems, the Iris report is 14 ± 2
35. On the DOS Keyboard, press the X Key.
36. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
37. Manually adjust the Collimator Rotation fully ↺ CCW.
38. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

For 9-inch Systems, the Iris report is 17 ± 2

For 12-inch Systems, the Iris report is 14 ± 2

39. On the DOS Keyboard, press the X Key.
40. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
41. In the Dose Area Product Calibration Window, in the box provided next to the Drive Iris To Button, click on the box containing the following iris position:

    For 9-inch System **300**

    For 12-inch System **195**

    Point and click on the Drive Iris To Button.
42. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 32 ± 2

    For 12-inch Systems, the Iris report is 27 ± 2
43. On the DOS Keyboard, press the X Key.
44. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
45. Manually adjust the Collimator Rotation to 180 ± 2.
46. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2

    For 9-inch Systems, the Iris report is 32 ± 2

    For 12-inch Systems, the Iris report is 27 ± 2
47. On the DOS Keyboard, press the X Key.
48. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.

49. In the Dose Area Product Calibration Window, in the box provided next to the Drive Iris To Button, click on the box containing the following iris position:

    For 9-inch System **350**

    For 12-inch System **260**

    Point and click on the DRIVE IRIS TO Button.

50. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 46 ± 2

    For 12-inch Systems, the Iris report is 40 ± 2

51. On the DOS Keyboard, press the X Key.

52. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.

53. Manually adjust the Collimator Rotation fully ↺ CCW.

54. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 46 ± 2

    For 12-inch Systems, the Iris report is 40 ± 2

55. On the DOS Keyboard, press the X Key.

56. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.

57. In the Dose Area Product Calibration Window, in the box provided next to the Drive Iris To Button, click on the box containing the following iris position:

    For 9-inch System **400**

    For 12-inch System **325**

    Point and click on the DRIVE IRIS TO Button.

58. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 61 ± 2

    For 12-inch Systems, the Iris report is 53 ± 2

59. On the DOS Keyboard, press the X Key.
60. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
61. Manually adjust the Collimator Rotation to 180 ± 2.
62. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 61 ± 2

    For 12-inch Systems, the Iris report is 53 ± 2

63. On the DOS Keyboard, press the X Key.
64. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
65. In the Dose Area Product Calibration Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **440**

    For 12-inch System **390**

    Point and click on the DRIVE IRIS TO Button.

66. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 73 ± 2

    For 12-inch Systems, the Iris report is 67 ± 2

67. On the DOS Keyboard, press the X Key.

68. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
69. Manually adjust the Collimator Rotation fully ↺ CCW.
70. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 73 ± 2

    For 12-inch Systems, the Iris report is 67 ± 2
71. On the DOS Keyboard, press the X Key.
72. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
73. In the Dose Area Product Calibration Window, in the box provided next to the Drive Iris To Button, click on the box containing the following iris position:

    For 9-inch System **470**

    For 12-inch System **450**

    Point and click on the Drive Iris To Button.
74. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 82 ± 2

    For 12-inch Systems, the Iris report is 78± 2
75. On the DOS Keyboard, press the X Key.
76. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
77. Manually adjust the Collimator Rotation to 180 ± 2.
78. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

For 9-inch Systems, the Iris report is 82 ± 2

For 12-inch Systems, the Iris report is 78 ± 2

79. On the DOS Keyboard, press the X Key.
80. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the Dose Area Product Calibration Window.
81. In the Dose Area Product Calibration Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

For 9-inch System **500**

For 12-inch System **500**

Point and click on the DRIVE IRIS TO Button.

82. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

For 9-inch Systems, the Iris report is 90 ± 2

For 12-inch Systems, the Iris report is 90 ± 2

83. On the DOS Keyboard, press the X Key.
84. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
85. Manually adjust the Collimator Rotation fully ↺ CCW.
86. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

For 9-inch Systems, the Iris report is 90 ± 2

For 12-inch Systems, the Iris report is 90 ± 2

87. On the DOS Keyboard, press the X Key.
88. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.

89. Point and click on the CALCULATE CONSTANTS Button. All constants except for the last two Iris Reports should be non-zero.
90. In the upper left-hand corner of the RUT Main Menu, point and click on **FILE.**
92. the SAVE CONFIGURATION AS Window, ensure that the Generator's Barcode followed by file extension .dap is displayed in the FILE NAME Box. Then point and click on the SAVE Button.
93. When the OVERWRITE Window appears, point and click on the YES Button.
94. In the upper left-hand corner of the RUT Main Menu, point and click on **FILE.**
95. Point, highlight and click on DOWNLOAD DAP DATA.
96. Reboot the system. Set the dosimeter for DOSE (RADS) and make a 10 second exposure at 70 kVp and 2 mA. Convert the Keithley reading as follows:

9 inch II:	Keithley reading times 0.372
12 inch II:	Keithley reading times 0.640.

The result should be within 10% of the DAP displayed on the Left Monitor.

Dose Area Product Calibration Using UtilitySuite

Note: For pre-OPIS system software, use the RUT utility CD.

For **Dual-leaf Collimators**, do steps 1 through 21 and 94 (N/A 22-95). You may use either a Kiethley or a Radcal dosimeter.

For **Single-leaf Collimators**, do steps 1 through 94, using a Kiethley dosimeter **only**.

Note: In order to activate the X key toggle, hold down the CTRL + ALT + M keys. Then, the X key on the DOS keyboard will toggle DAP On and Off.

*Note: The **DOS keyboard** is the peripheral keyboard connected to the Workstation, typically used in conjunction with the small monochrome monitor.*

1. Position the 150/180cc dosimeter ion chamber in the center of the Image Intensifier. See the instructions just above about which brand dosimeter may be used.
2. On the Generator's Control Panel, select Manual Fluoro Mode and open the Collimator and Iris Leafs completely.
3. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter and Iris reports are ≤1.
4. On the DOS Keyboard press the X Key.
5. In UtilitySuite, go to RUT and connect.Click on DOSE AREA PRODUCT CALIBRATION in the left window.
6. At the top of the DAP CALIBRATION Window, ensure that the proper Image Intensifier Size, and the proper number of Collimator Leafs, for the system under test, are set.
7. Manually adjust the technique to 40 kVp and 5 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
8. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
9. Manually adjust the technique to 50 kVp and 5 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
10. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
11. Manually adjust the technique to 60 kVp and 4 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
12. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
13. Manually adjust the technique to 80 kVp and 3 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
14. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
15. Manually adjust the technique to 100 kVp and 2 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.
16. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
17. Manually adjust the technique to 120 kVp and 2 mA. While taking an X-ray, for approximately 10 seconds, read the dosimeter and record the Dose Rate in mR/sec.

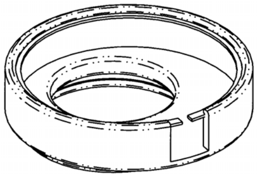
18. Record the Dose Rate in mR/second and mA in the DAP Tube Calibration Grid.
19. Point and click on the CALCULATE COEFFICIENTS Button.
20. Click on FILE->Save As->Workstation File .
21. In the SAVE dialog Window, ensure that the Generator’s Barcode followed by file extension.dap is displayed in the FILE NAME Box. Then point and click on the SAVE Button.

For dual-leaf collimators only: skip steps 22-94, do step 94.

For single-leaf collimators only: complete this Section up to this point, then continue with steps 22 - 94.

Note: During this portion of the DAP Calibration, if the Collimator Iris, Leaf, or Rotation does not drive to the specified report number (plus or minus), simply adjust it into the correct range using the manual controls on the Mainframe’s Control Panel. The utility’s job is just to get the parameter in the ball-park for the convenience of the technician.

22. Install the DAP Fixture Tool (P/N 00-882027-01), with the Kiethley 150 cc ion chamber inserted in it, onto the collimator cover.



DAP Fixture Tool

23. On the Generator’s Control Panel, manually close the Collimator Leaf completely.
24. On the Generator’s Control Panel, set the technique to 80 kVp and 3 mA. Manually adjust the Collimator Rotation fully ↺ CCW, **then fully open the iris manually.**
25. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **185**

    For 12-inch System **60**

    Point and click on the DRIVE IRIS TO Button.

26. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is ≤ 2

    For 12-inch Systems, the Iris report is ≤ 2

27. On the DOS Keyboard, press the X Key.
28. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
29. Manually adjust the Collimator Rotation to 180 ± 2.
30. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is ≤2

    For 12-inch Systems, the Iris report is ≤ 2

31. On the DOS Keyboard, press the X Key.
32. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
33. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **250**

    For 12-inch System **130**

    Point and click on the DRIVE IRIS TO Button.

34. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2

    For 9-inch Systems, the Iris report is 17 ± 2

    For 12-inch Systems, the Iris report is 14 ± 2

35. On the DOS Keyboard, press the X Key.

36. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
37. Manually adjust the Collimator Rotation fully ↺ CCW.
38. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 17 ± 2

    For 12-inch Systems, the Iris report is 14 ± 2
39. On the DOS Keyboard, press the X Key.
40. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
41. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **300**

    For 12-inch System **195**

    Point and click on the DRIVE IRIS TO Button.
42. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 32 ± 2

    For 12-inch Systems, the Iris report is 27 ± 2
43. On the DOS Keyboard, press the X Key.
44. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
45. Manually adjust the Collimator Rotation to 180 ± 2.
46. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2

   For 9-inch Systems, the Iris report is 32 ± 2

   For 12-inch Systems, the Iris report is 27 ± 2

47. On the DOS Keyboard, press the X Key.
48. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
49. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **350**

    For 12-inch System **260**

    Point and click on the DRIVE IRIS TO Button.

50. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 46 ± 2

    For 12-inch Systems, the Iris report is 40 ± 2

51. On the DOS Keyboard, press the X Key.
52. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
53. Manually adjust the Collimator Rotation fully ↺ CCW.
54. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 46 ± 2

    For 12-inch Systems, the Iris report is 40 ± 2

55. On the DOS Keyboard, press the X Key.
56. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.

57. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **400**

    For 12-inch System **325**

    Point and click on the DRIVE IRIS TO Button.

58. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 61 ± 2

    For 12-inch Systems, the Iris report is 53 ± 2

59. On the DOS Keyboard, press the X Key.

60. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.

61. Manually adjust the Collimator Rotation to 180 ± 2.

62. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 61 ± 2

    For 12-inch Systems, the Iris report is 53 ± 2

63. On the DOS Keyboard, press the X Key.

64. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.

65. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **440**

    For 12-inch System **390**

    Point and click on the DRIVE IRIS TO Button.

66. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 73 ± 2

    For 12-inch Systems, the Iris report is 67 ± 2

67. On the DOS Keyboard, press the X Key.
68. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
69. Manually adjust the Collimator Rotation fully ↺ CCW.
70. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 73 ± 2

    For 12-inch Systems, the Iris report is 67 ± 2

71. On the DOS Keyboard, press the X Key.
72. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
73. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **470**

    For 12-inch System **450**

    Point and click on the DRIVE IRIS TO Button.

74. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

    For 9-inch Systems, the Iris report is 82 ± 2

    For 12-inch Systems, the Iris report is 78± 2

75. On the DOS Keyboard, press the X Key.

76. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
77. Manually adjust the Collimator Rotation to 180 ± 2.
78. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 82 ± 2

    For 12-inch Systems, the Iris report is 78 ± 2
79. On the DOS Keyboard, press the X Key.
80. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
81. In the DOSE AREA PRODUCT CALIBRATION Window, in the box provided next to the DRIVE IRIS TO Button, click on the box containing the following iris position:

    For 9-inch System **500**

    For 12-inch System **500**

    Point and click on the DRIVE IRIS TO Button.
82. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, Rotation report is 180 ± 2.

    For 9-inch Systems, the Iris report is 90 ± 2

    For 12-inch Systems, the Iris report is 90 ± 2
83. On the DOS Keyboard, press the X Key.
84. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
85. Manually adjust the Collimator Rotation fully ↺ CCW.
86. Take a Fluoro X-ray, then on the DOS Keyboard press the X Key. On the DOS Monitor, on the DAP_CMP Report line, ensure that the Shutter report is ≥ 97.5, the Rotation report is 0 ± 2.

For 9-inch Systems, the Iris report is 90 ± 2

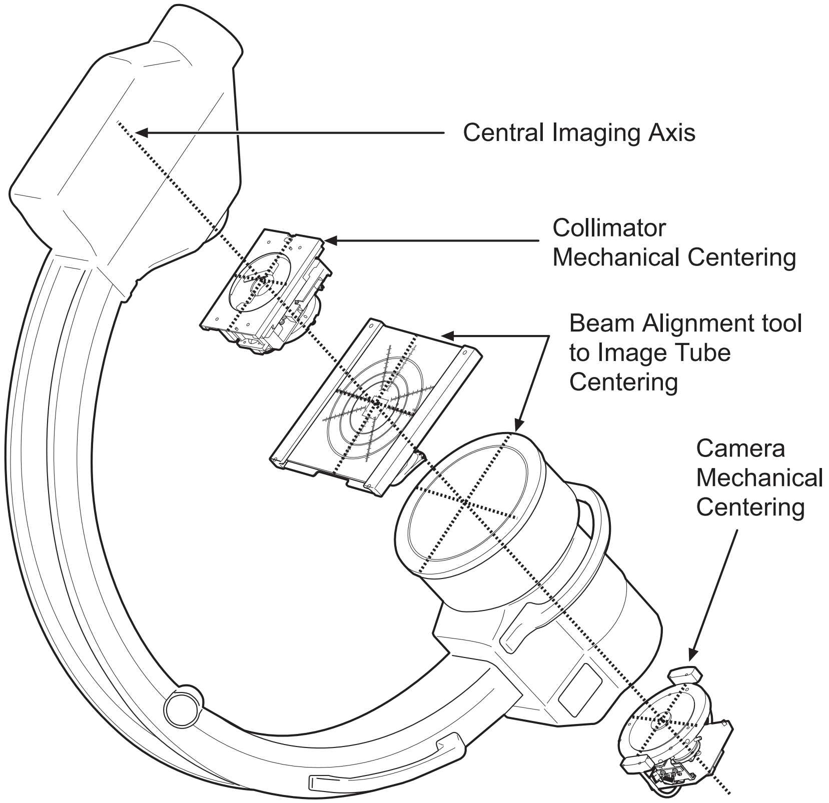
For 12-inch Systems, the Iris report is 90 ± 2

87. On the DOS Keyboard, press the X Key.
88. Take a Normal Fluoro X-ray for at least 10 seconds, read and record the Dose Rate in mR/sec. Enter this value in the correct corresponding box in the DOSE AREA PRODUCT CALIBRATION Window.
89. Point and click on the CALCULATE CONSTANTS Button. All constants except for the last two Iris Reports should be non-zero.
90. Click on **FILE->Save As->Workstation File.**
91. In the SAVE dialog Window, ensure that the Generator's Barcode followed by file extension .dap is displayed in the FILE NAME Box. Then point and click on the SAVE Button.
92. When the OVERWRITE Window appears, point and click on the YES Button.
93. Click on **FILE->Save->To System->Workstation.**
94. Reboot the system. Set the dosimeter for DOSE (RADS) and make a 10 second exposure at 70 kVp and 2 mA. Convert the Keithley reading as follows:

9 inch II:	Keithley reading times 0.372
12 inch II:	Keithley reading times 0.640.

The result should be within 10% of the DAP displayed on the Left Monitor.

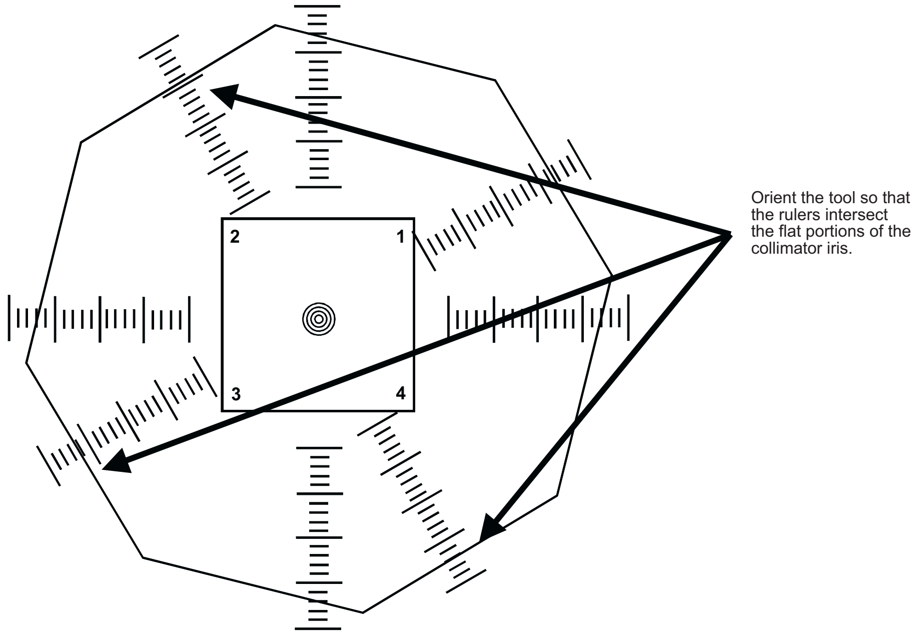
Beam Alignment


Central Imaging Axis
Collimator
Mechanical Centering
Beam Alignment tool
to Image Tube
Centering
Camera
Mechanical
Centering

Components Affecting Beam Alignment

Beam Alignment Tool to Image Tube Centering

1. Attach the beam alignment tool to the face of the image tube.
2. Align the beam alignment tool to the center of the image tube, so that when the collimator iris is closed partially, the ruller marks on the tool intersect the flat portions of the collimator iris (see the following diagram).


2
1
3
4
Orient the tool so that the rulers intersect the flat portions of the collimator iris.

Centering Beam Alignment Tool to Image Tube Center

Image Tube Calibration

Image Tube Sizing Verification

1. Fluoro through the beam alignment tool in Normal, Mag1, Mag2 modes and verify the following diameter measurements on the monitor. (These measurements are made with circular blanking turned on).
2. Use the ruler marks that intersect the center of the flat portion of the collimator iris leaves to determine the X & Y image diameters.

Mag Size	9 Image Tube	12 Image Tube	9 Image Tube on Super C
Normal	208 - 216 MM diameter	283 - 290 MM diameter	206 - 212 MM diameter
Mag1	136 - 144 MM diameter	199 - 207 MM diameter	150 - 156 MM diameter
Mag2	116 - 124 MM diameter	147 - 154 MM diameter	112 - 118 MM diameter

3. When measuring the image diameters, verify no collimator iris or leaves are seen inside of the circular blanking,
4. If the image diameters are outside of the ranges listed above adjust the image tube power supply as required (see *Image Tube Sizing Calibration*, in the following section.

Image Tube Sizing Calibration

1. Remove the cover on the side of the image tube housing to gain access to the power supply adjustments.
2. On the image tube power supply, set switch SW1 to the OFF position.
3. Adjust the image tube size encoder to obtain the proper image tube diameters in Normal. Mag1, and Mag2 modes. (These adjustments may change the image tube focus).

4. When the image sizing adjustments are complete, set switch SW1 to the ON position on the Image Intensifier Power Supply, as shown in the following:

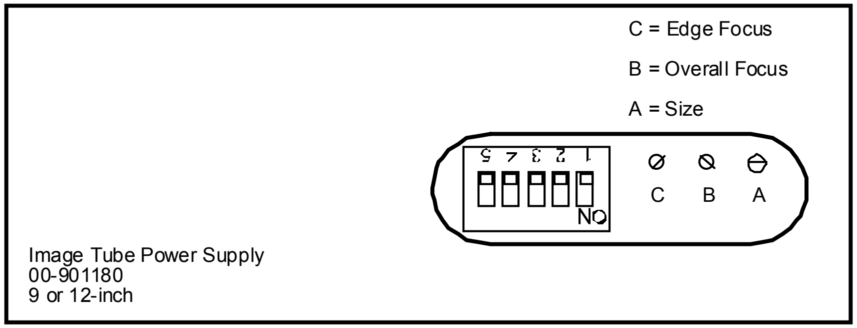

C = Edge Focus
B = Overall Focus
A = Size
5 4 3 2 1
ON
C
B
A
Image Tube Power Supply
00-901180
9 or 12-inch

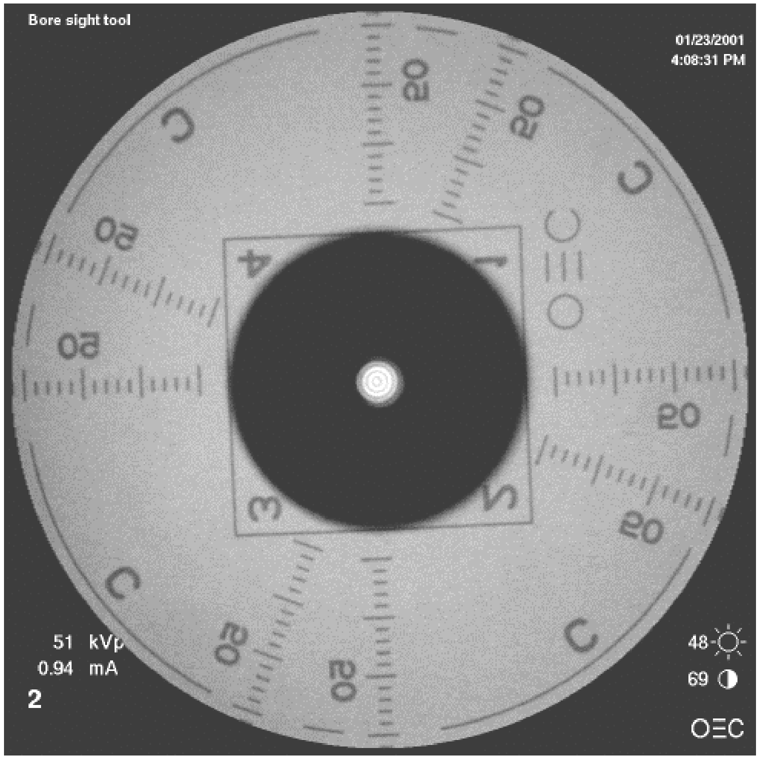
Image Tube Power Supply Access

Image Tube Electronic Centering Verification

1. With the beam alignment tool attached to the image tube, make a MAG2 exposure and mark the center of the alignment tool with a small dot using a marker.
2. Change to the Normal MAG size and make an exposure. Verify that in center of the alignment tool is within 4 MM of the mark made using MAG2.

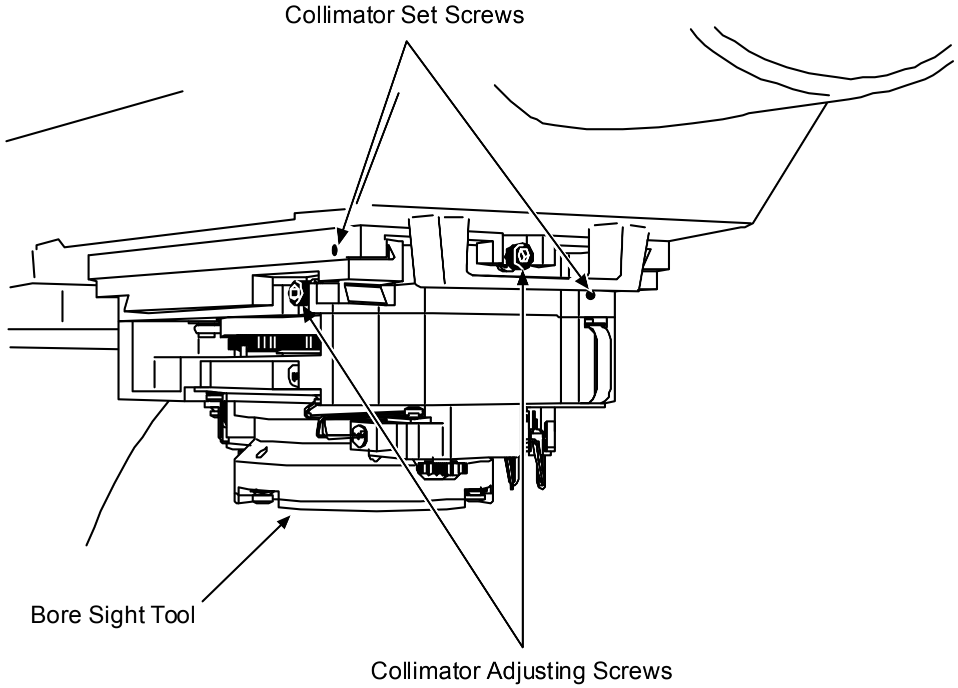
Collimator Mechanical Centering

1. Verify centering as follows:
    a. Attach the bore site tool to the collimator.
    b. Select MAG2 and make an exposure, the collimator should be centered as shown.


Bore sight tool
01/23/2001
4:08:31 PM
51 kVp
0.94 mA
2
48
69
OEC

Collimator Mechanical Centering

2. Mechanically center collimator as follows:
   a. With the bore site tool attached to the bottom of the collimator, loosen the collimator set screws (see following picture).

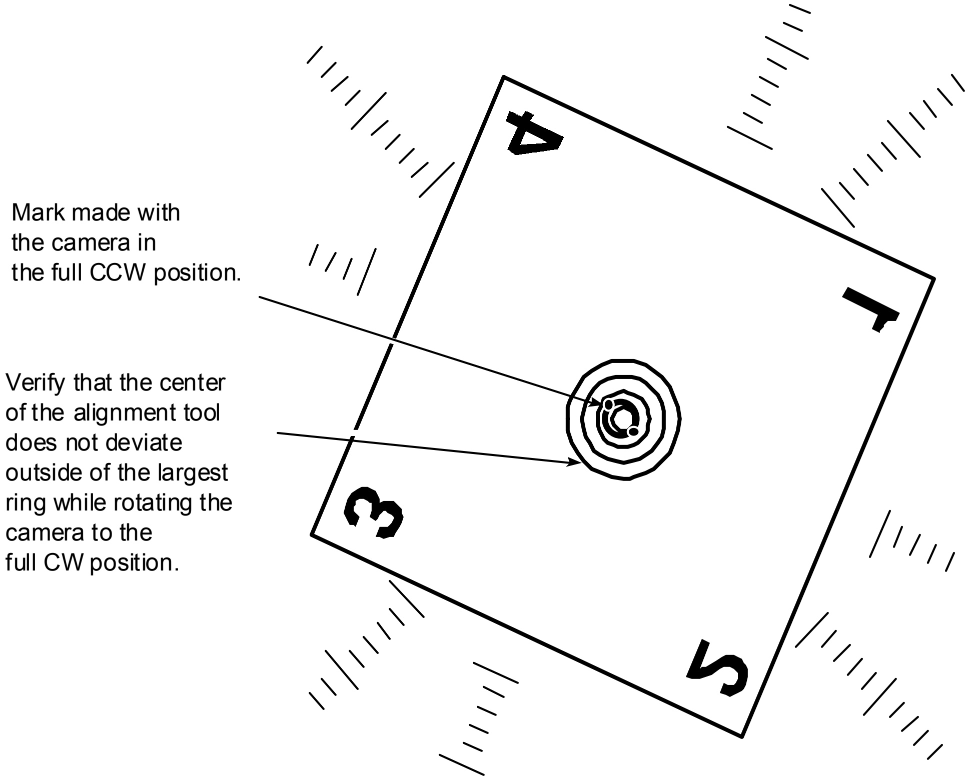

Collimator Set Screws
Bore Sight Tool
Collimator Adjusting Screws

Adjustment of Collimator Centering

3. Center the collimator in reference to the beam alignment tool using the collimator adjusting screws.
4. When the collimator is centered properly, tighten the collimator set screws.
5. Remove bore site tool.

Camera Decentration

1. Verify camera decentration as follows:
    a. Select the MAG1 mode.
    b. Rotate the CCD Camera to the full Counter clockwise position.
    c. X-ray through the beam alignment tool and mark the center of the alignment tool on the monitor with a small dot using an erasable marker.
    d. While making a Fluoro exposure, rotate the camera completely through its rotational travel and verify that the dot made with the marker does not deviate outside the largest ring in the center of the beam alignment tool (see following picture).
2. Calibrate Camera Decentration as follows:
    a. Select the MAG1 mode.
    b. Rotate the CCD Camera to the full Counter clockwise position.
    c. X-ray through the beam alignment tool and mark the center of the beam alignment tool on the left monitor with a small dot using an erasable marker.
    d. Rotate the camera 90º clockwise (90ºfrom full counter clock wise) and make another exposure and mark the center of the beam alignment tool on the monitor.
    e. Rotate the camera another 90º clockwise (180ºfrom full counter clockwise) and make another exposure, mark the center of the beam alignment tool on the monitor.

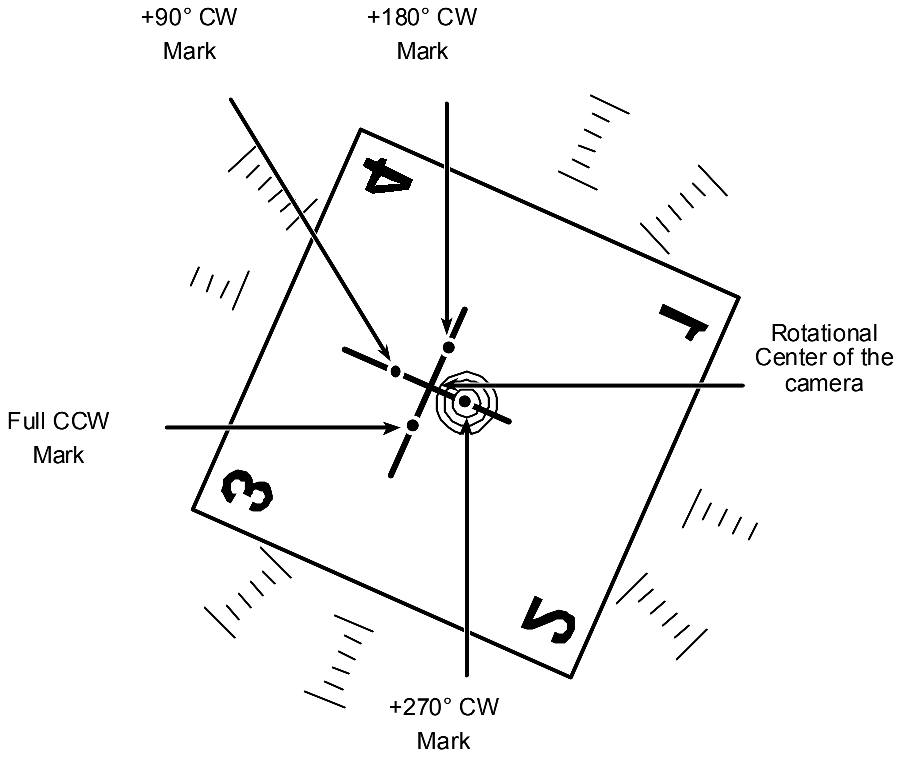


Mark made with
the camera in
the full CCW position.

Verify that the center
of the alignment tool
does not deviate
outside of the largest
ring while rotating the
camera to the
full CW position.

Verifying Camera Decentration

f. Rotate the camera another 90º clockwise (270ºfrom full counter clockwise) and make another exposure, mark the center of the beam alignment tool on the monitor as indicated on the following diagram.


+90° CW
Mark
+180° CW
Mark
4
1
Rotational
Center of the
camera
Full CCW
Mark
3
5
+270° CW
Mark

Calibrating Camera Decentration

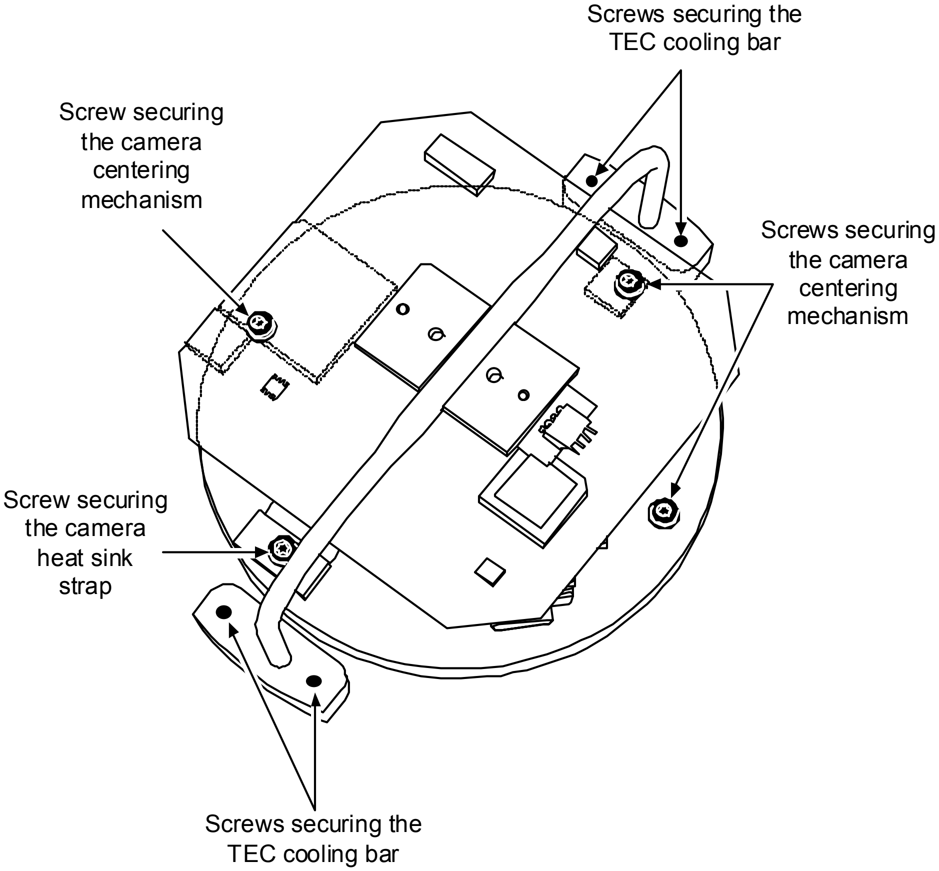
g. Draw two lines intersecting the 4 marks made on the monitor, the point where the lines cross each other is the rotational center of the camera.

h. Rotate the camera to the center of its rotational range.

i. Loosen but do not remove the following screws in the camera assembly:

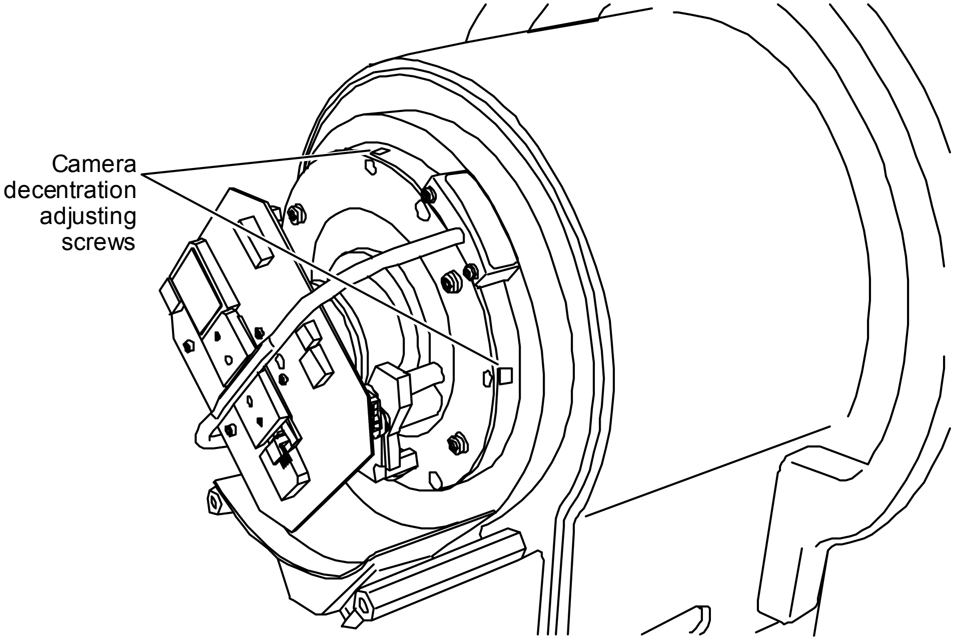
- 4 screws securing the Thermal Electric Cooling bar.
- 3 screws securing the camera centering mechanism.
- 1 screw securing the camera heat sink strap.

Note: Do ***not*** *loosen the 3 screws securing the camera to the back of the image tube.*


Screws securing the TEC cooling bar
Screw securing the camera centering mechanism
Screws securing the camera centering mechanism
Screw securing the camera heat sink strap
Screws securing the TEC cooling bar

Loosen But Do Not Remove These Screws

j. While making a Fluoro exposure adjust the camera decentration screws to align the rotational center of the camera to the center of the beam alignment tool as indicated in the following picture.



Aligning the Camera Rotational Center

k. Tighten the screws of step (i) above.

l. Check the accuracy of the decentration adjustment by repeating above step 1, (a) through (d).

Note: For adjustment of the camera centering relative to the circular mask, refer to Collimator/Camera Calibration section, later in this chapter.

Collimator Alignment Verification

1. Attach the beam alignment tool to the image tube.
2. Fluoro in the Normal field, no collimator iris or leaves should be visible in the image.
3. Fluoro in Mag1 & Mag2, verify that no collimator iris or leaves are seen in the image
4. Measure the X & Y diameters of the image, the measured diameters must fall within the ranges listed.
5. Use the ruler marks that intersect the center of the flat portions of the collimator iris to determine the X & Y image diameters (see the following table).

Image Tube Size	**Maximum Visible Diameter**	**Minimum Visible Diameter**
9 Inch Normal Mode	216 MM	208 MM
9 Inch Mag1	144 MM	136 MM
9 Inch Mag2	124 MM	116 MM
12 Inch Normal Mode	290 MM	283 MM
12 Inch Mag1	207 MM	199 MM
12 Inch Mag2	154 MM	147 MM
9 Normal Mode on Super C	212 MM	206 MM
9 Mag 1 on Super C	156 MM	150 MM
9 Mag 2 on Super C	118 MM	112 MM

6. Close the collimator iris to its minimum position. Fluoro and verify that the collimated beam is smaller than the box on the beam alignment template.
7. Move the collimator Iris and leaves without making a Fluoro exposure. Verify that the collimator preview circles and lines are displayed on the left monitor. Fluoro and verify that the preview circles and lines, and the actual collimated image line up

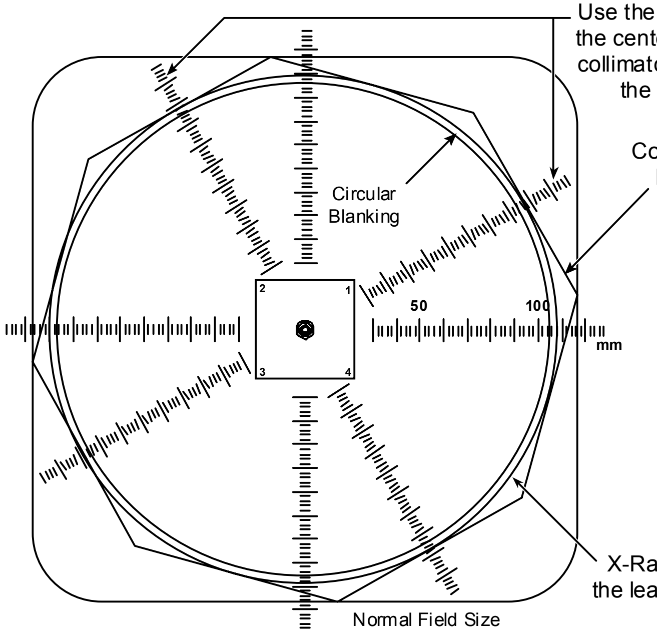
within .5 inches of each other. (If the preview circles and lines are not seen, or are more than .5 inches out of position, re-calibration of the collimator is required).

8. Rotate the camera and verify that the camera rotation symbols appear and move properly during camera rotation. The image on the left monitor should automatically change to the new rotational setting when the camera rotation button is released. (If the camera rotation preview symbols are not seen or do not rotate in the correct direction, re-calibration of the camera rotation is required).

Note: For pre-OPIS system software, use the RUT utility CD.

9. Connect the RUT cable to the laptop and the back of the workstation.
10. If using RUT
    a. Run the RUT program and Connect
    b. Select the Collimator/Camera Calibration form. (Do not Upload or Download any data)
    c. Skip step 11, and go to step 12.
11. If using UtilitySuite:
    a. Select the View Pull down menu and select RUT.
    b. Select the File Pull down menu and select New then 9800.
    c. Select the Connect Pull down menu and System. When asked if you want the forms updated with data retrieved from the system? Answer Yes. As data is retrieved from the system, you will see the serial and barcode numbers for the system appear on the form.
    d. Select the Collimator/Camera Setup form.
12. Uncheck the Show Circular Mask box on the form. (This will remove the circular blanking from the images on the monitors).
13. Fluoro in the Normal, Mag1, and Mag2 fields (see next diagram).
    a. In the Normal field, no collimator blades should be visible in the image and no more than 2 iris sections should be visible at the edge of the field.
    b. In Mag1 and Mag2, no more than 2 iris sections of the collimator should be visible at the edge of the field. If more than 2 iris sections of the collimator are visible, the collimator sizing or centering is out of adjustment.

14. Check the Show Circular Mask box on the form and disconnect the laptop.
17. Insert a film envelope into the Beam Alignment Tool.
18. Expose the film in the following collimator iris positions (see the following diagrams):
    - Normal field
    - Mag1 field
    - Mag2 field
    - Minimum iris position

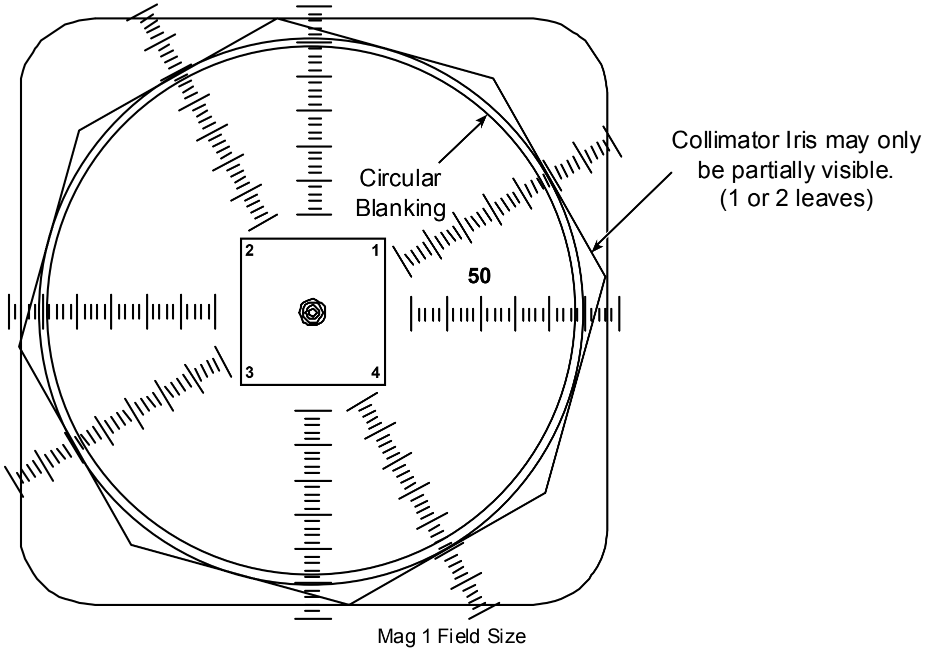


Use the ruler marks that intersect the center of the flat portion of the collimator iris leaves to determine the X & Y film diameters.

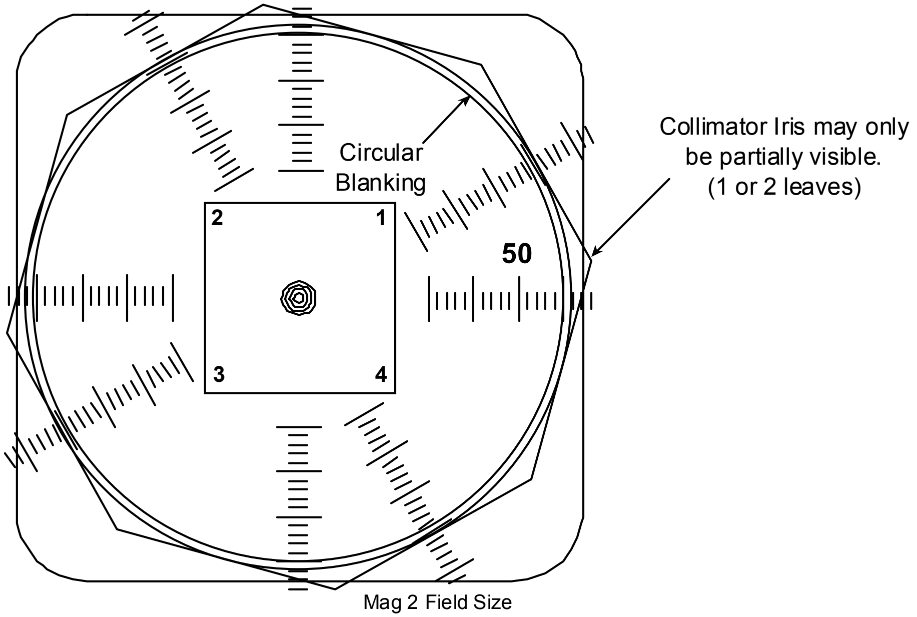
Collimator Iris may only be partially visible. (1 or 2 leaves)

X-Ray beam produced by the lead ring in the collimator

Normal Field Size


Circular Blanking
Collimator Iris may only be partially visible. (1 or 2 leaves)
50
1
2
3
4
Mag 1 Field Size

Mag 1 Field Size


Circular Blanking
Collimator Iris may only be partially visible. (1 or 2 leaves)
2
1
3
4
50
Mag 2 Field Size

Mag 2 Field Size

19. Develop the film.
20. Use the ruler marks that intersect the center of the flat portion of the collimator iris to determine the X & Y film diameters.

21. Verify that the field diameters on the film are within the following tolerances:

Mag Size	9 Image Intensifier Film	12 Image Intensifier Film
Normal	222 MM diameter +/- 4 MM	296 MM diameter +0 MM -4 MM
Mag1	150 MM diameter +0 MM -4 MM	222 MM diameter +0 MM -4 MM
Mag2	130 MM diameter +0 MM -4 MM	150 MM diameter +0 MM -4 MM

22. Record the measured film and Image diameters in a copy of the table below.
23. Subtract the Image and Film diameters for each X & Y axis and enter it as the difference. (Typically about 10 MM, must be less than 28 MM to be within tolerance 3% SID).
24. Add the X & Y differences for each field size and enter it as the Sum. (Typically about 20 MM, must be less than 36 MM to be within tolerance 4% SID).

Field Size	Film Diameter	Image Diameter	Difference < 28 MM (3% SID)	Sum < 36 MM (4% SID)
Normal X				
Normal Y				
Mag1 X				
Mag1 Y				
Mag2 X				
May2 Y				

Collimator / Camera Calibration

Note: For pre-OPIS system software, use the RUT utility CD.

Using RUT

1. Attach the beam alignment tool to the image tube.
2. Connect the RUT cable to the laptop and the back of the workstation.
3. Run the RUT program.
4. From the Tools pull down menu select Connect, then Upload and Save to save all data from the 9800 to the laptop.
5. Select the Collimator / Camera form
6. Click on the Calibrate Collimator Stops button and follow the instructions that appear on the laptop.
7. Click on the Normal Mode button and follow the instructions that appear on the laptop.
8. Click on the Mag Modes button and follow the instructions that appear on the laptop.
9. Click on the Calibrate Camera Stops button and follow the instructions that appear on the laptop.
10. Click on the Enable Camera Adjustment button and follow the instructions that appear on the laptop.
11. From the File pull down menu select the Save Collimator / Camera Calibration File to save the new calibration data.
12. From the File pull down menu select the Download Collimator / Camera Data to 9800 to apply the data to the 9800.
13. From the Tools pull down menu, select Disconnect.
14. Turn the 9800 system off, wait for about 10 seconds then turn the system back on. If collimator related error messages appear, the data downloaded was bad or the download was unsuccessful.
15. Repeat the Collimator Alignment Verification in the preceding section.

Using UtilitySuite

1. Attach the beam alignment tool to the image tube
2. Orient the tool on the image tube so that when the collimator iris is closed partially, the ruler marks on the tool intersect the flat portions of the collimator iris.
3. Connect the utility cable to the laptop and the back of the workstation.
4. Start the UtilitySuite program.
5. Select the View pull down menu and select RUT.
6. Select the File pull down menu and select New then 9800.
7. Select the Connect pull down menu and System. When asked, **DO YOU WANT THE FORMS UPDATED WITH DATA RETRIEVED FROM THE SYSTEM?** Select Yes. As data is retrieved from the system, you will see the serial and barcode numbers for the system appear on the form.
8. Select the Collimator / Camera form and select Hide under Circular Mask.

Note: The Hide selection on the form allows you to see the X-ray images with or without the circular blanking applied to the image.

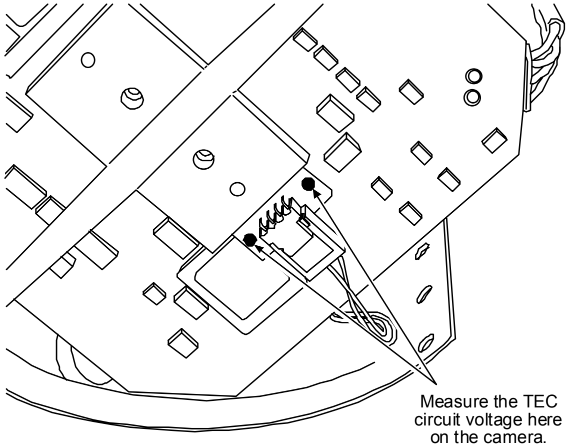
9. Click on the Calibrate Stops button. It takes about two minutes to complete this part of the calibration, (watch for the hour glass symbol to disappear)..
10. Click on the Calibrate Mag Modes button on the form and follow the instructions on the laptop.
11. Click on the Calibrate Normal Mode button and follow the instructions that appear on the laptop.
12. Select Show under Circular Mask.
13. Click on the Enable Camera Adjustment button and follow the instructions that appear on the laptop.
14. Use the X and Y sliders on the form to center the image to the circular mask on the monitor, making Fluoro exposures to see the image move each time you move the slider.
15. Click on the Disable Camera Adjustment button on the form. This will prevent the camera and collimator preview lines from being reversed.

16. Select the File pull down menu, select Save, To System, and Both. The message **YOU MUST REBOOT THE SYSTEM IN ORDER FOR THE SAVED DATA TO BE APPLIED TO THE SYSTEM** will be displayed.
17. Click on Ok. Turn the 9800 system off, wait for about 10 seconds then turn the system back on.

Camera Calibration

Camera Cooler Verification

1. Attach a DMM to the two solder pads on the TEC board on the camera (see following diagram).
2. Measure the voltage between the solder pads on the TEC circuit board. The voltage should change from 0 to 3-5 volts DC approximately every 20 seconds while the system is running.



Camera Cooler Test Points

Camera Iris

Note: For pre-OPIS system software, use the RUT utility CD.

Iris Stop Verification

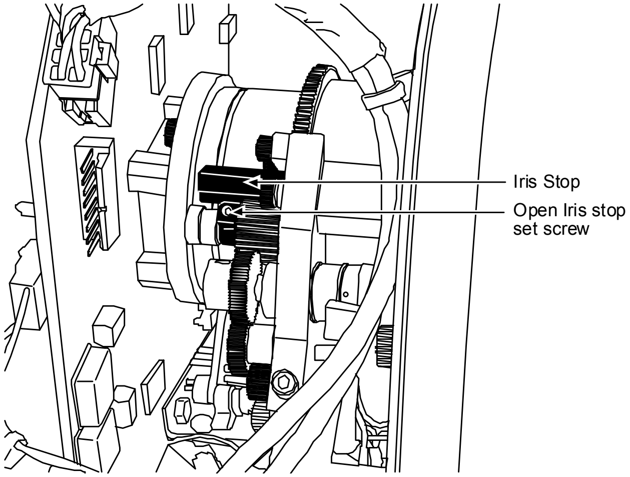
1. Before verifying the camera iris setup, ensure that the collimator cover and image tube focus grid are in place on the system.
2. Using RUT (or open UTILITY SUITE, go to RUT and connect), verify that the Generator Sync rate is to 30 Hz. and the Domestic ABS table is selected. (If Sync rate and ABS table settings are different, temporarily change them to verify or calibrate the Camera Iris).
3. Place 2 millimeters of copper on the collimator cover so that the entire X-ray beam passes through it.
4. Attach a suitable dosimeter ion chamber to the center of the focus grid on the image tube.
5. Verify that the following image tube input doses are produced while making NORMAL Magnification mode Auto Fluoro exposures through the copper filters (Dose corrected for temperature and elevation):
   - 9-inch I.I. – 4.5 ±0.3 mR/minute
   - 12-inch I.I – 3.3 ±0.2 mR/minute
6. Verify that the following closed iris image tube input doses are produced while making NORMAL magnification mode 30 PPS HLF exposures:
   - 9-inch I.I. – 32 ± 3.0 mR/minute
   - 12-inch I.I – TBD ± TBD mR/minute

   Re-calibration of the camera iris is required if the image tube input dose is outside of the ranges listed above.
7. If system settings were changed in step 2, restore the settings now.
8. Remove the copper from the collimator cover and the ion chamber from the center of the focus grid.

Iris Stop Calibration

1. Before verifying the camera iris setup, ensure that the collimator cover and image tube focus grid are in place on the system.
2. Using RUT (or open UtilitySuite, go to RUT and connect), verify that the Generator Sync rate is to 30 Hz. and the Domestic ABS table is selected. (If Sync rate and ABS table settings are different, temporarily change them to verify or calibrate the Camera Iris).
3. Place 2 millimeters of copper on the collimator cover so that the entire X-ray beam passes through it.
4. Attach a suitable dosimeter ion chamber to the center of the focus grid on the image tube.
6. Loosen the open iris stop set screw using a 6 flute Bristol Spline tool (see next picture).

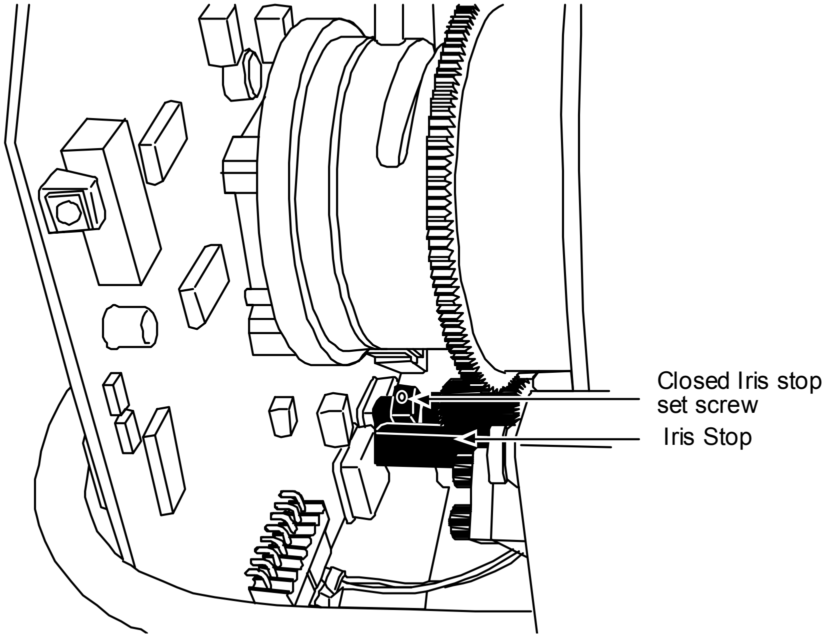
Note: Do not attempt to loosen the set-screw using a hex wrench.



Open Iris Stop Set Screw

7. While making an Auto Fluoro exposure in the Normal Magnification mode, move the iris gears to obtain image tube input doses according to the preceeding section.
8. Without moving the position of the iris gears, swing the open iris stop up against the iris stop and tighten the set screw to 10 ounce-inches.
9. Repeat the *Iris Stop Verification* procedure in the previous section.
10. If the system has the 30 PPS HLF option available, proceed to the next step, otherwise go to the C*ameraLens Focus* section following.
11. Loosen the closed iris stop set screw using a 6 flute Bristol Spline tool (see next picture).
12. While making an exposure in the Auto Fluoro exposure in the Normal Magnification mode, move the iris gears to obtain the following image tube input dose:
    - 9-inch I.I. – 16 ± 2.0 mR/minute
    - 12-inch I.I. – 11.6 ± 1.5 mR/minute
13. Without moving the position of the iris gears, swing the closed iris stop up against the iris stop and tighten the set screw to 10 ounce-inches (see following picture).
14. Repeat the *Iris Stop Verification* procedure in the previous section.

Note: The doses set in step 12 are not the verified amounts specified in the Verification instructions in the previous section.



Closed Iris Stop Set Screw

Lens Focus

Focus Verification

1. Attach a resolution tool to the face of the focus grid near the center at a 45º angle (see drawing, *Beam Alignment* section, previously in this chapter).
2. Turn off *Auto Histo.*Use brightness and contrast adjustments to view resolutions.
3. Verify that the following minimum resolutions can be seen in the image:

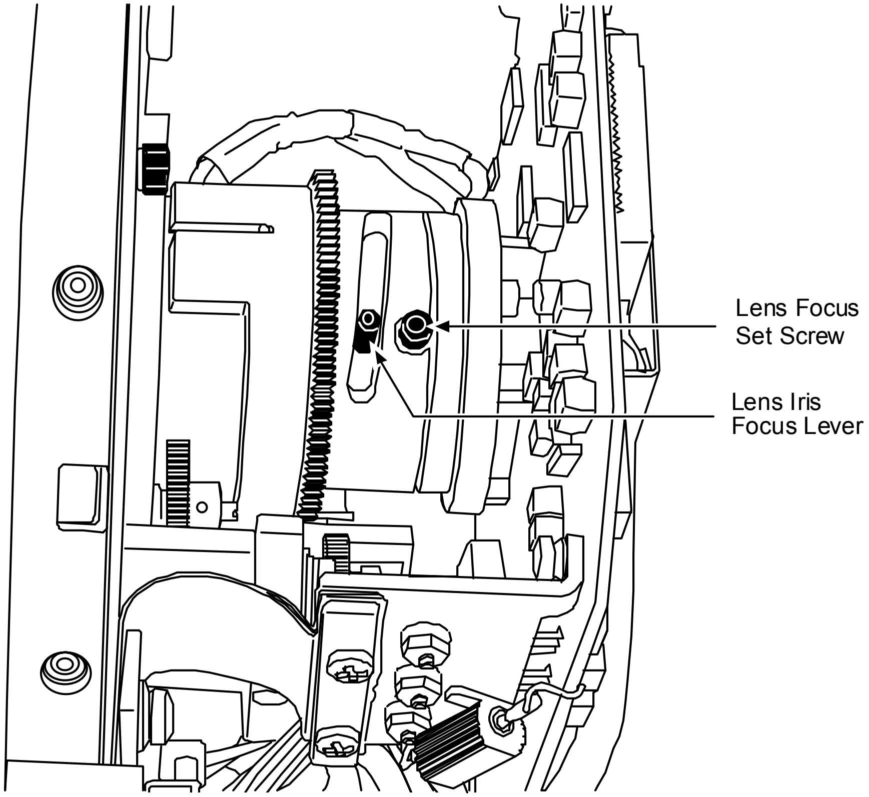
II Size	Minimum Resolution
9 Normal Field	2.3 LP/MM
9 Mag 1	3.2 LP/MM
9 Mag 2	3.8 LP/MM
12 Normal Field	1.7 LP/MM
12 Mag 1	2.3 LP/MM
12 Mag 2	3.0 LP/MM

Focus Adjustment

1. Attach a resolution tool to the face of the focus grid near the center at a 45º angle.
2. Carefully loosen the Lens Focus Set Screw.
3. Adjust the focus using the Lens Iris Focus Lever.

Note: On some systems you may have to slightly loosen the Lens Iris Focus Lever to get it to move.

4. Retighten the Lens Focus Set Screw (and Lens Iris Focus Lever---see following picture).


Lens Focus
Set Screw
Lens Iris
Focus Lever

Lens Focus Set Screw and Iris Focus Lever

Monitor Setup

Note: All adjustments to the monitors and light sensor should be performed only after the monitors have reached normal operating temperature. Usually a minimum of 1 hour is required.

Monitor Size

Note: For pre-OPIS system software, use the RUT utility CD.

Verification Using RUT

1. Connect the utility cable to the laptop and the back of the workstation.
2. Run the RUT program. From the Tools pull down menu, select Connect, then Upload and Save to save all data from the 9800 to the laptop.
3. Select the Workstation Calibration form
4. Click on the Monitor pull down button select the left monitor.
5. Click on the Test Patterns pull-down button and select Monitor/Camera Alignment. The beam alignment pattern appears on the left monitor.
6. Verify that the pattern on the left monitor measures 10” by 10”. If the pattern does not measure 10” by 10”, the monitor needs resizing (see *Calibration* procedures following).

Verification Using Utility Suite

1. Connect the utility cable to the laptop and the back of the workstation.
2. Start the Utility Suite software.
3. Select the View Pull down menu and select “RUT”.

4. Select the File Pull down menu and select New then 9800.
5. Select the Connect Pull down menu and System. When asked if you want the forms updated with data retrieved from the system, select Yes. As data is retrieved from the system, you will see the serial and barcode numbers for the system appear on the form.
6. Select the Monitor Calibration form.
7. From the Display Test Patterns pull down, and select Beam Alignment. The beam alignment patterns will display on the left monitor.
8. Verify that the pattern on the left monitor measures 10” by 10”. If the pattern does not measure 10” by 10”, the monitor needs resizing (see *Calibration* procedures following).

Calibration Using RUT

1. If the pattern **sizing** needs adjustment use the Vertical and Horizontal sliders on the form to make the pattern measure 10 by 10.
2. If the pattern **centering** needs adjustment use the X and Y Position Sliders to center the pattern on the monitor.
3. Click on the Monitor pull down button and select the right monitor.
4. Click on the Test Patterns pull-down button and select Monitor/Camera Alignment.
5. Use the sliders on the form to size and center the right monitor.
6. From the File pull down menu select the Save Workstation Calibration File to save the new monitor calibration data.
7. From the File pull down menu select the Download Workstation Calibration data to the 9800.
8. From the Tools pull down menu select Disconnect.
9. Turn the 9800 system off, wait for about 10 seconds, then turn the system back on.

Calibration Using Utility Suite

1. To adjust monitor size, select the Enable Monitor Adjustment Turn Off Light Sensor button and use the Vertical and Horizontal sliders on the form to make the pattern measure 10” by 10”.

2. If the pattern centering needs adjustment use the X and Y Position Sliders to center the pattern on the monitor.
3. To check the alignment of the right monitor. Click on the Right tab on the form and repeat the steps for the left monitor alignment.
4. If changes are made in monitor sizing, save the changes to the system by selecting the File pull down menu and selecting Save, then To System, then Both. The message ”**YOU MUST REBOOT THE SYSTEM IN ORDER FOR THE SAVED DATA TO BE APPLIED TO THE SYSTEM**” will display. Click on “Ok”. Turn the 9800 system off, wait for about 10 seconds then turn the system back on.

Monitor Light Settings

Note: For pre-OPIS system software, use the RUT utility CD.

Using the RUT Utility CD

1. Connect the RUT cable to the laptop and the back of the workstation.
2. Run the RUT program. From the Tools pull down menu select Connect, then Upload and Save to save all data from the 9800 to the laptop.
3. Select the Workstation Calibration form
4. Click on the Monitor pull down button; and select the Left monitor.
5. Select minimum light settings by clicking on one of the minimum brightness or contrast sliders.

Note: Click at the top of the pointer on the slider. This will help prevent inadvertently changing the setting when you select it.

When a slider is selected it will have a red box around it allowing you to use the right and left arrows on the laptop keyboard to make fine adjustments.

6. Using a light meter verify that the black and white panels on the center of the monitor produce the following minimum light levels:

Minimum Light Settings	
Black Panel light level	**White Panel light level**
0.70 to .085 Foot Lamberts	145 to 155 Foot Lamberts

7. Carefully (see Note of step 5) select maximum light settings by clicking on one of the maximum brightness or contrast sliders.
8. Using a light meter, verify that the black and white panels on the center of the monitor produce the following maximum light levels:

Maximum Light Settings	
Black Panel light level	White Panel light level
1.1 to 1.25 Foot Lamberts	195 to 205 Foot Lamberts

9. Click on the Monitor pull down button select the Right monitor.
10. Repeat the Minimum and Maximum light setting adjustment for the right monitor
11. When both monitors produce the correct light levels select the File pull down menu and select the Save Workstation Calibration File to save the new monitor brightness and contrast calibration data.
12. From the File pull down menu select the *Download Workstation Calibration data to the 9800.*
13. From the Tools pull down menu select Disconnect.
14. Turn the 9800 system off, wait for about 10 seconds then turn the system back on.

Using the Utility Suite CD

1. Connect the utility cable to the laptop and the back of the workstation.
2. Start the Utility Suite software.

3. Select the View Pull down menu and select RUT.
4. Select the File Pull down menu and select New then 9800.
5. Select the Connect pull down menu, and click on System. When asked if you want the forms updated with data retrieved from the system, select Yes. As data is retrieved from the system, you will see the serial and barcode numbers for the system appear on the form.
6. Select the Monitor Calibration form.
7. From the Display Test Patterns Pull down, select Gray Scales. The Gray Scale pattern will be displayed on the left monitor.
8. Select the Enable Monitor Adjustment turn off light sensor button.
9. Select the Enable Minimum Adjust.
10. Select one of the minimum brightness or contrast sliders.

Note: Click on top of the pointer on the slider. This will help prevent inadvertently changing the setting when you select it.

When a slider is selected it will have a dotted box around it allowing you to use the right and left arrows on the laptop keyboard to make fine adjustments.

11. Using a light meter, verify that the black and white panels on the center of the monitor produce the following light levels:

Minimum Light Settings	
Black Panel light level	**White Panel light level**
0.70 to .085 Foot Lamberts	145 to 155 Foot Lamberts

12. Carefully (see Note of step 10) select the Enable Max Adjust by selecting one of the maximum brightness or contrast sliders.
13. Using a light meter verify that the black and white panels on the center of the monitor produce the following light levels:

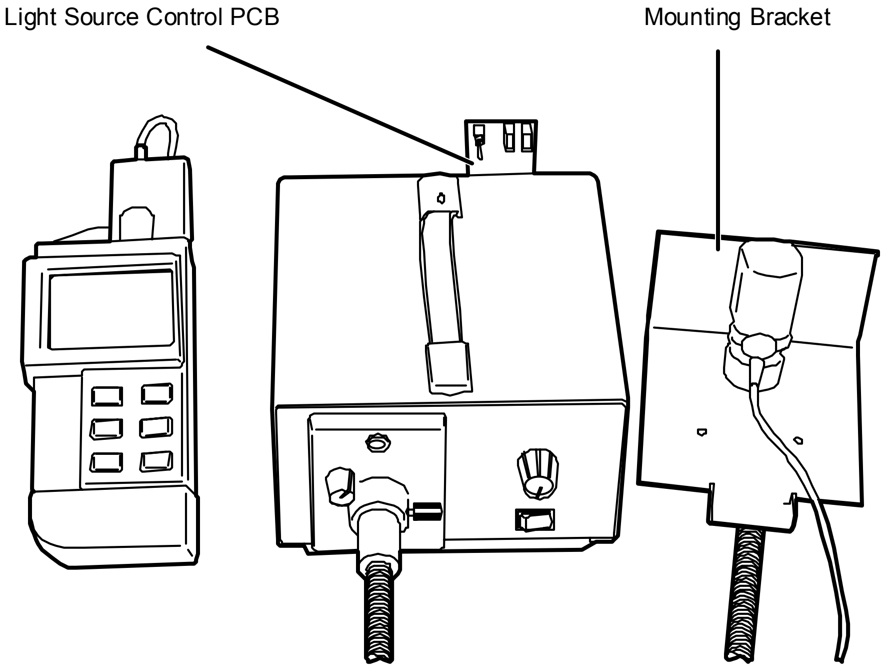
Maximum Light Settings	
Black Panel light level	**White Panel light level**
1.1 to 1.25 Foot Lamberts	195 to 205 Foot Lamberts

14. To check the alignment of the right monitor Click on the Right tab on the form and repeat the steps for the left monitor alignment.
15. If changes are made in monitor brightness and contrast settings, save the changes to the system by selecting the File pull down menu, Save, then To System ,then Both. The message **YOU MUST REBOOT THE SYSTEM IN ORDER FOR THE SAVED DATA TO BE APPLIED TO THE SYSTEM** will be displayed. Click on Ok.
16. Turn the 9800 system OFF, wait for about 10 seconds then turn the system back ON.

Light Source Verification / Calibration

The following equipment is required to calibrate and verify the light source.

- Light meter
- Fostec light source and head with mounting bracket.
- Fostec light source control PCB

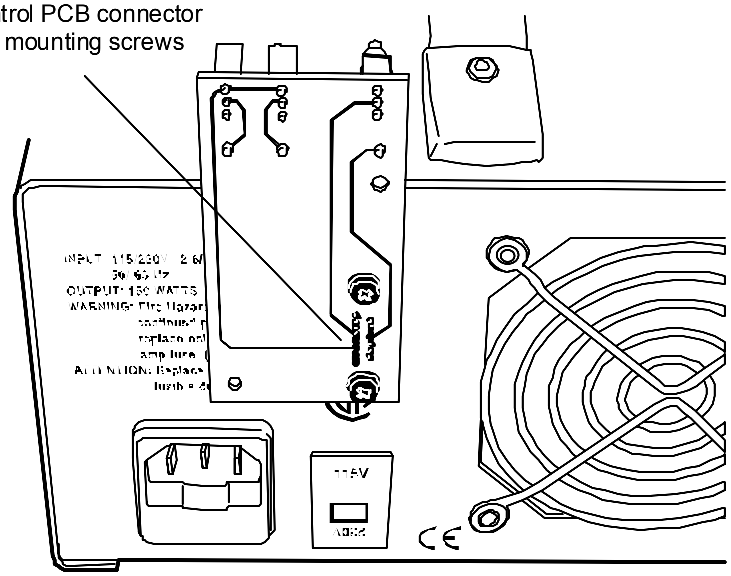


Light Source Setup

Light Source Verification

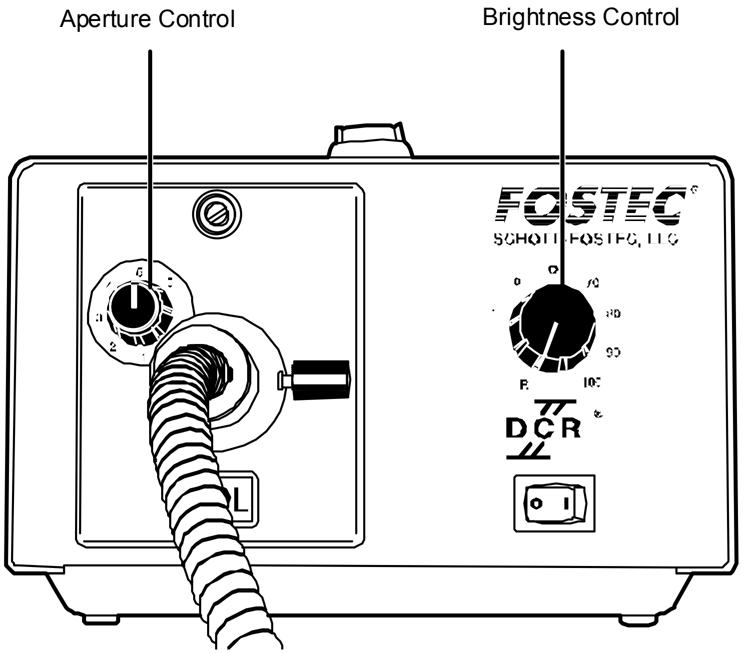
1. Mount the Fostec Light Source Control PCB onto the connector labeled NOT RS232 at the rear of the Fostec Light Source.
2. On the Fostec light source front panel, turn the aperture control to the number 5 position.
3. Turn the brightness control knob to the remote (R) position, (CCW).
4. Attach the fiber optic cable to the light source.

5. Use the light meter to calibrate the output of the light source. Place the light meter sensor over the hole in the mounting bracket. (The light meter sensor must completely cover the hole in the bracket to prevent any additional light from leaking into the meter).
6. Turn on the Fostec Light Source and let it warm up for about 30 seconds.
7. Move the switch on the light source control PCB to the LOW position (down). A reading of 1.7 Foot Lamberts +/-0.1 should be produced by the light source.
8. Move the switch on the light source control PCB to the HIGH position (down). A reading of 21 Foot Lamberts +/-0.5 should be produced by the light source.
9. If both switch settings produce light levels that are too high or too low, adjust the aperture control knob slightly to correct the light output.
10. If both readings cannot be obtained from a single aperture setting when changing between the HIGH and LOW switch positions, the light source control board will need to be aligned (see *Calibration* procedures following).



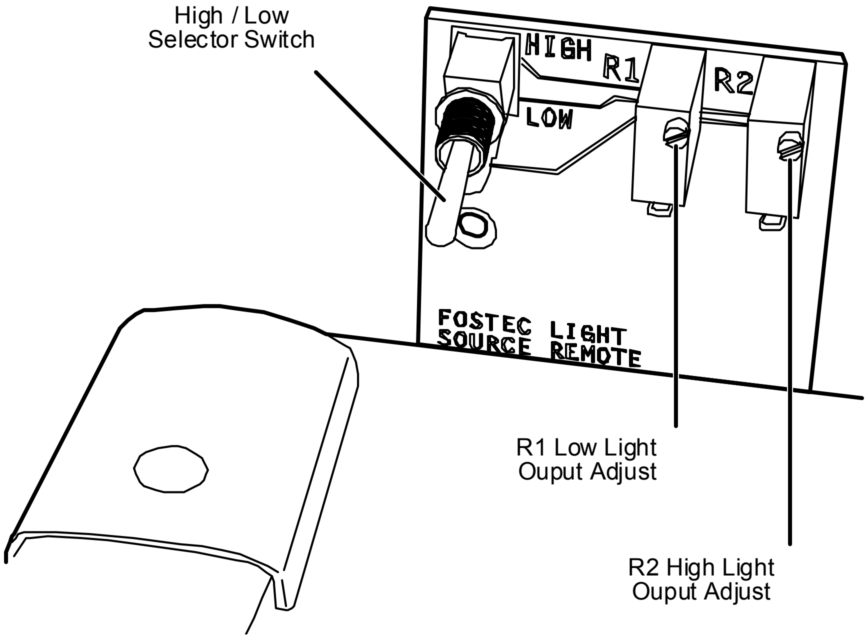
Fostec Light Source
Control PCB connector
and mounting screws

INPUT: 115/230V 2.6/
50/60 Hz
OUTPUT: 150 WATTS
WARNING: Fire Hazar
continued p
replace onl
amp fuse.
ATTENTION: Replace
fusible d
115V
230V


Aperture Control
Brightness Control
FOSTEC
SCHOTT-FOSTEC, LLC
DCR

Light Source Calibration

1. Move the switch on the light source control PCB to the LOW position (down).
2. Turn on the light source and let it stabilize for about 10 seconds.
3. Adjust R1 on the light source control PCB to obtain a reading of 1.7 Foot Lamberts +/-0.1 on the light meter.
4. Move the switch on the light source control PCB to the HIGH position (up) and let it stabilize for about 10 seconds.
5. Adjust R2 on the light source control PCB to obtain a reading of 21 Foot Lamberts +/-0.5 on the light meter.


High / Low
Selector Switch
HIGH
LOW
R1
R2
FOSTEC LIGHT
SOURCE REMOTE
R1 Low Light
Ouput Adjust
R2 High Light
Ouput Adjust

Light Sensor Verification / Calibration

Note: All adjustments to the monitors and light sensor should be performed only after the monitors have reached normal operating temperature. Usually a minimum of 1 hour is required.

The following equipment is required to calibrate and verify the light sensor.

- Light meter
- Fostec light source and head with mounting bracket.
- Fostec light source control PCB

Light Sensor Verification

1. Verify that the light source is producing the proper light output in the HIGH and LOW switch settings.
2. Place the light source holding bracket over the workstation light sensor.
3. Turn the 9800 system on and let it boot completely.

4. Using the photometer, verify that the black and white areas on the left monitor are producing the following illumination levels.

Simulated Minimum Light Settings	
Black Panel light level	**White Panel light level**
0.70 to 0.85 Foot Lamberts	145 to 155 Foot Lamberts

Simulated Maximum Light Settings	
Black Panel light level	**White Panel light level**
1.10 to 1.25 Foot Lamberts	195 to 205 Foot Lamberts

Light Sensor Calibration Using Rut

Note: For the following procedure, use the RUT utility CD.

1. Verify that the Fostec Light Source is properly adjusted.
2. Place the light source holding bracket over the workstation light sensor.
3. Connect the RUT cable to the laptop and the back of the workstation.
4. Run the RUT program. From the *Tools* pull down menu select *Connect*, then *Upload and Save* to save all data from the 9800 to the laptop.
5. Select the *Workstation Calibration* form. Click on the *Calibrate Light Sensor* button at the bottom of the form and follow the instructions appearing on the laptop.
6. After completing the instructions on the laptop, select the *File* pull down menu and select the *Save Workstation Calibration File* to save the new light sensor calibration data.
7. From the *File* pull down menu select the *Download Workstation Calibration data to the 9800*.
8. From the *Tools* pull down menu select *Disconnect*.

9. Turn the 9800 system off, wait for about 10 seconds then turn the system back on.
10. Perform the light sensor verification test.

Light Sensor Calibration Using Rut

Note: For the following procedure, use the Utility Suite CD.

1. Verify that the Fostec Light Source is properly adjusted.
2. Place the light source holding bracket over the workstation light sensor.
3. Connect the utility cable to the laptop and the back of the workstation.
4. Start the Utility Suite software.
5. Select the View Pull down menu and select RUT.
6. Select the File Pull down menu and choose New, then 9800.
7. Select the Connect pull down menu and click on System. When asked if you want the forms updated with data retrieved from the system, select Yes. As data is retrieved from the system, you will see the serial and barcode numbers for the system appear on the form.
8. Select the Monitor Calibration form.
9. Click on the Calibrate Light Sensor button at the bottom of the form and follow the instructions appearing on the laptop simulating minimum and maximum lighting conditions.
10. While simulating, the minimum and maximum lighting conditions select the Read Light Sensor button. The reading should be as follows:
    - Near 100 for maximum lighting conditions.
    - Near 10 for minimum lighting conditions.
11. Save the changes to the system by selecting the File pull down menu and choosing Save, then To System, then Both. The message **YOU MUST REBOOT THE SYSTEM IN ORDER FOR THE SAVED DATA TO BE APPLIED TO THE SYSTEM** will be displayed. Click on OK.

12. Turn the 9800 system OFF, wait for about 10 seconds then turn the system back ON.
13. Perform the light sensor verification test.

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WARNING: *Please read each replacement procedure completely and make sure you understand all associated safety messages before attempting to do the work. Failure to observe safety precautions may result in death, personal injury, or equipment damage.*

Note: Refer to the C-arm Subsystem chapter of this manual if you need help locating a C-Arm component.

Equipment Covers

WARNING: *Exposed C-Arm circuitry is extremely dangerous EVEN WHEN SYSTEM IS NOT CONNECTED TO AN AC OUTLET. Residual charges on X-ray tube, high voltage cables, image intensifier, high energy electrolytic capacitors, and batteries can kill or injure on contact. Charges can remain at lethal levels days or months after you unplug system from AC line.*

WARNING: *Never allow anyone to use the system when any C-Arm cover is removed. Failure to heed this warning may result death, personal injury, or equipment damage.*

The C-Arm has several covers that protect the operator and patient from dangerous electric shock and other possible injuries, and protect the equipment from damage. The following instructions explain how to safely loosen or remove these covers prior to equipment maintenance.

WARNING: *Use extreme caution if you intend to troubleshoot the equipment with the covers off and power applied. Failure to heed this warning can result in death, personal injury, or equipment damage.*

You must remove generator covers in the following sequence:

1. Front cover
2. Right side cover
3. Rear cover
4. Left side cover
5. Front leg cover

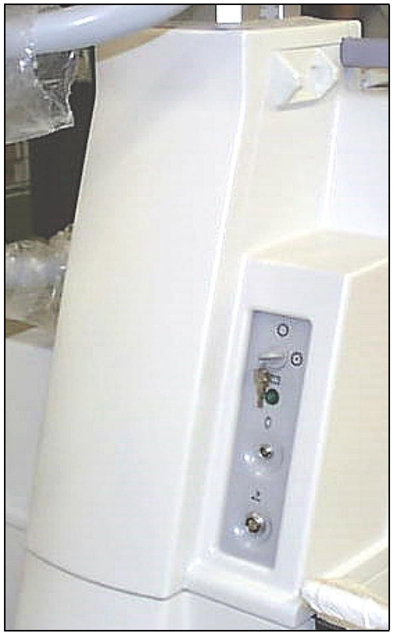
You can remove the Cross Arm Bearing cover, X-ray Tube connector cover, and CCD Camera cover in any order. You cannot remove the Collimator cover until the X-ray Tube Connector cover is off. You must remove the Cross Arm Bearing cover before you can remove either Control Panel cover.

Front Cover

***WARNING**: Removing the front cover exposes dangerous AC line voltages on the Power/Motor Relay PCB. Disconnect Workstation from AC line before touching this PCB.*

You must remove the front cover before you can remove the right side cover, rear cover, left side cover, or front leg cover. Proceed as follows:

1. Disconnect Workstation’s AC power plug from AC outlet.
2. Loosen four screws that secure front cover to C-Arm. Screws are located in horizontal top portion of front cover under a flexible collar that surrounds vertical column.
3. Lift cover away from C-Arm.



Front Cover

Right Side Cover

***WARNING**: Disconnect Workstation from AC line and disconnect battery pack from C-Arm before discharging high energy electrolytic capacitors. Failure to heed this message may result in death, personal injury, or severe equipment damage.*

WARNING: *Removing right side cover exposes extremely dangerous voltages on Capacitor/Power module. Charges on capacitors can remain at lethal levels long after you unplug system from AC line. Unplug Workstation from AC line, and discharge capacitors in accordance with following instructions before touching any circuitry.*

You must remove the right side cover before you can remove the rear cover, left side cover, or front leg cover. Follow these steps to remove the right side cover:

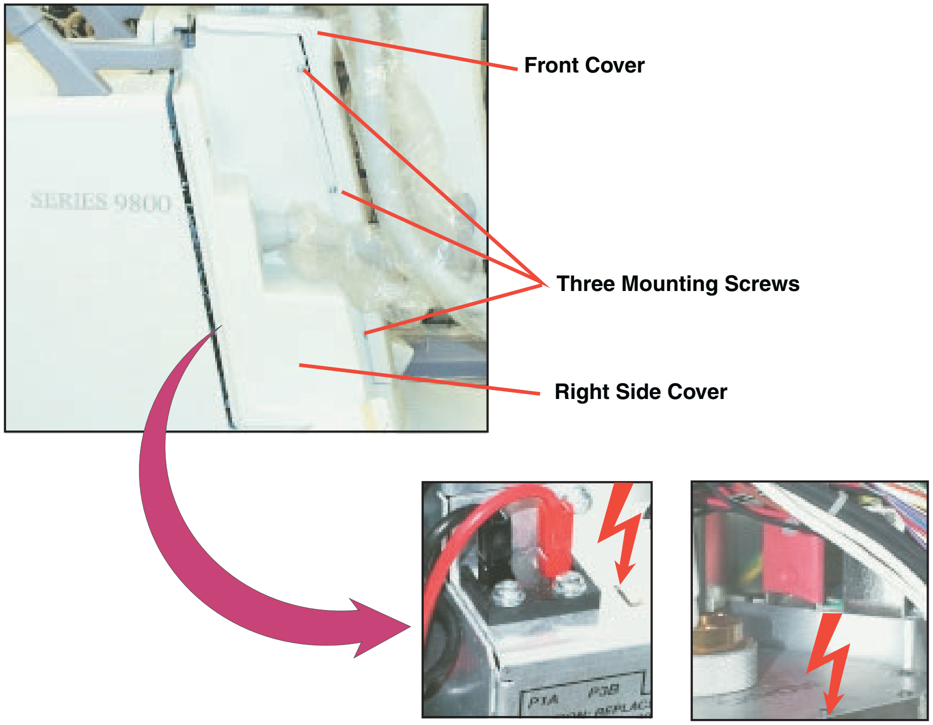
1. Make certain Workstation's AC power plug is disconnected from AC outlet.
2. Turn off battery breaker.
3. Remove front cover as described in previous screen.
4. Remove and retain three screws that secure front edge of right side cover to generator.
5. Slowly move right side cover forward over Interconnect Cable and High Voltage Cable toward the C. Move cover far enough forward to give unrestricted access to component you wish to service.
5. Using great care to avoid electric shock, use a VOM to check across capacitor bus bars for residual charge on high energy capacitors. If any charge is present, connect a 300k, half-watt resistor across capacitor bus bars to discharge capacitors.

Rear Cover

WARNING: *Disconnect Workstation from AC line and disconnect battery pack from C-Arm before discharging high energy electrolytic capacitors. Failure to heed this message may result in death, personal injury, or severe equipment damage.*

WARNING: *Removing right side cover exposes extremely dangerous voltages on Capacitor/Power module. Charges on capacitors can remain at lethal levels long after you unplug system from AC line. Unplug Workstation from AC line, and discharge capacitors in accordance with following instructions before touching any circuitry.*

The rear cover protects most of the C-Arm electronics, so it will probably be the cover you remove most often. You must remove the rear cover before you can remove the left side cover or front leg cover. Follow these steps:


Front Cover
Three Mounting Screws
Right Side Cover
SERIES 9800

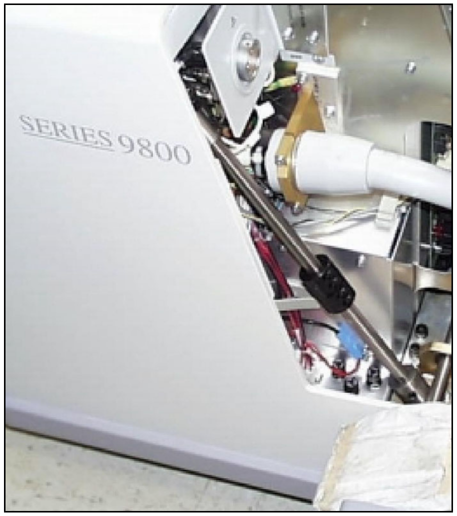
P3B

High Energy
Capacitor
Bus Bars

Right Side Cover Details

1. Make certain Workstation's AC power plug is not connected to AC outlet.
2. Turn off battery breaker.

3. Remove Front cover and Right Side cover.
4. Using great care to avoid electric shock, make certain there is no residual charge on high energy electrolytic capacitors. If you have not already done so, use a VOM to check voltage on capacitor bus bars. If any charge is present, connect a 300k, half-watt resistor across capacitor bus bars and let capacitors discharge.
5. Loosen coupler that connects steering handle and shaft to C-Arm steering mechanism. You may need to rotate steering handle to gain access to screws in coupler.
6. Remove and retain two screws from bottom front corners of rear cover.
7. Snap open certification document container at top of rear cover, and pull certification documents forward to expose three rear cover mounting screws.
8. Remove and retain rear cover mounting screws.
9. Lift rear cover up and off C-Arm.



Rear Cover Details

Left Side Cover

***WARNING**: Removing the left side cover exposes dangerous AC line voltages on the Power/Signal Interface PCB, Power Supply PS1, Power Supply PS2, Column Power Supply PS3, power transformers T2 and T3, and motor start capacitor C5 and motor phase-shifting capacitor C13. Disconnect Workstation from AC line before touching any of these assemblies.*

You must remove the left side cover before you can remove the front leg cover. Follow these steps to remove the left side cover:

1. Make certain Workstation's AC power plug is disconnected from AC outlet.
2. Turn off battery breaker.
3. If hand control or footswitch are connected, unplug them and set them aside.
4. Remove Front cover, Right Side cover, and Rear cover as described previously.
5. Loosen three screws that secure front edge of Left Side cover to C-Arm.
6. Lift Left Side cover away from generator.
7. Using great care to avoid electric shock, make certain there is no residual charge on high energy electrolytic capacitors. If you have not already done so, use a VOM to check voltage on capacitor bus bars. If any charge is present, connect a 300k, half-watt resistor across capacitor bus bars to discharge capacitors.

Left Side Cover

Front Leg Cover

The front leg cover does not protect any exposed circuitry and does not block access to any mechanical assemblies. However, it does protect wiring that runs between the Vertical Column Lift and other C-Arm circuitry. It is unlikely you will ever have to remove the cover unless it is physically damaged, or you must replace the Front Casters orVertical Column Lift. Follow these steps to remove the front leg cover:

1. Disconnect Workstation’s AC power plug from AC outlet.

2. Remove front cover, right side cover, rear cover, and left side cover as described in previous screens.
3. Remove and retain eight screws that secure front leg cover to generator.
4. Lift front leg cover away from generator.

Front Leg Cover Details

X-ray Tube Connector Cover

The X-ray tube connector cover protects the high voltage, stator, temperature sensor and thermal cutout cables, and other terminals on the X-ray tube. You must remove this cover before replacing the X-ray tube or removing the Collimator cover. Follow these steps:

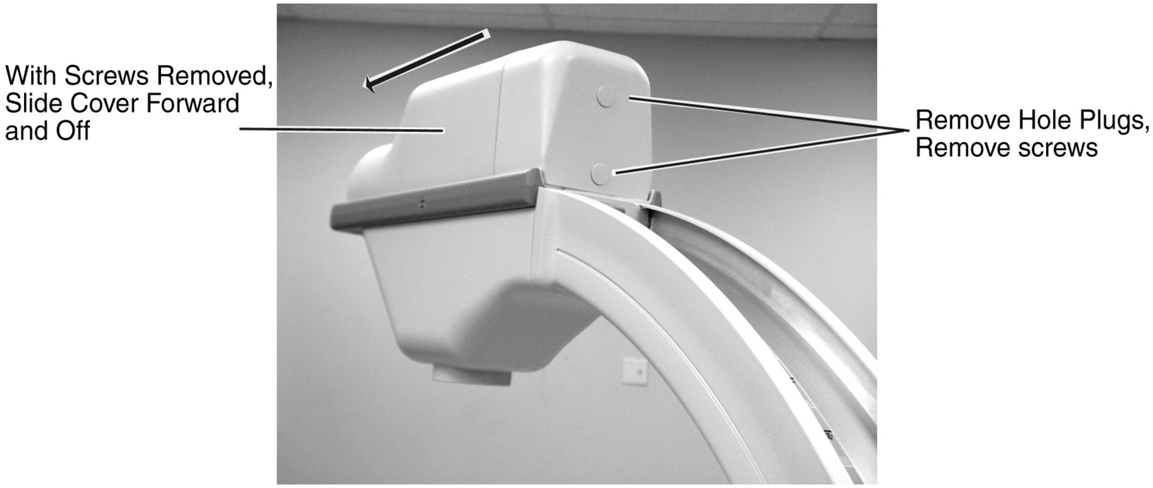
1. Disconnect Workstation's AC power plug from AC outlet.
2. Remove and retain two hole plugs that conceal X-ray tube connector cover's mounting screws.
3. Remove and retain torx mounting screws that secure X-ray tube connnector cover to X-ray tube.
4. Carefully slide X-ray tube connector cover back over high voltage cables far enough to give you access to X-ray tube connectors and Collimator cover mounting screws.

X-ray Tube Connector Cover

Collimator Cover

The Collimator cover is easy to remove. Follow these steps:

1. Make certain Workstation’s AC power plug is disconnected from AC outlet.
2. Remove X-ray tube connector cover as described in previous screen.
3. Remove and retain two torx screws that secure Collimator cover.
4. Slide Collimator cover forward and lift it off Collimator.


With Screws Removed,
Slide Cover Forward
and Off
Remove Hole Plugs,
Remove screws

Collimator Cover Details

CCD Camera Cover

***CAUTION**:* *Don't touch the CCD camera unless you're wearing a grounded wrist strap. Damage to camera circuitry from electrostatic discharge may otherwise occur.*

Two screws hold the CCD camera cover in place (see *CCD Camera and Cover* section, later in this chapter). The location of these screws varies depending on image intensifier size. Refer to the following illustration to locate the screws on a 9-inch or 12-inch image intensifier, and follow these steps:.

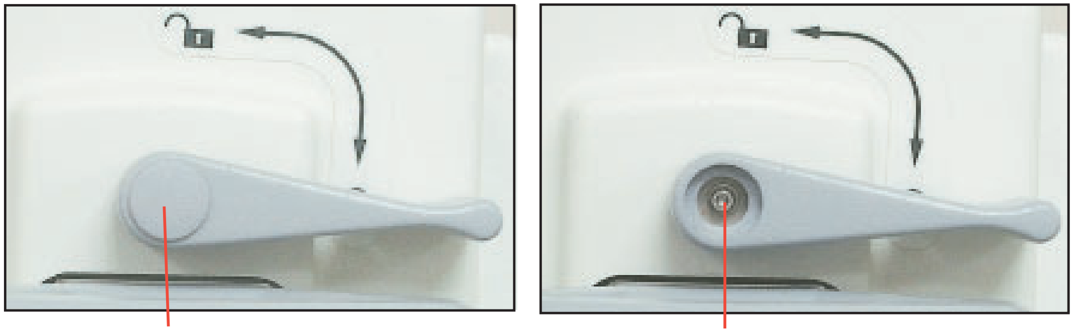
1. Disconnect Workstation's AC power plug from AC outlet.
2. Remove and retain screws to release the CCD camera cover.

Cross Arm Bearing Cover

***Note**:* *If you decide to completely remove the Cross Arm Bearing cover from the Cross Arm assembly, tag each connector and wire harness to help you reinstall the cover later.*

This procedure describes how to loosen the Cross Arm bearing cover to gain access to the Control Panel Processor PCB, Control Panel Processor I/O PCB, the Cross Arm Bearing assembly, and the mounting screws for the two Control Panel assemblies.

1. Disconnect Workstation power cord from AC outlet.
2. Make sure Horizontal Extension brake is set.
3. Remove and retain cap and screw from Horizontal Extension brake handle.
4. Pull loosened brake handle from brake shaft. Retain handle.



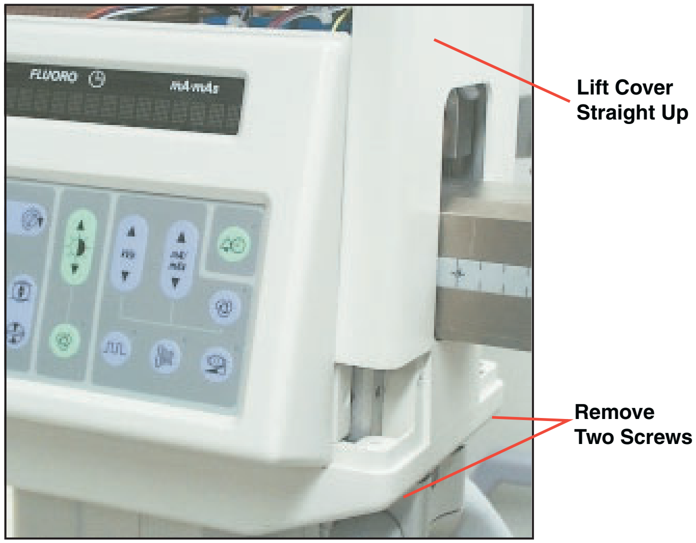
Remove Cap

Remove Screw

Horizontal Extension Brake Handle Removal

5. Remove two screws that secure front legs of Cross Arm Bearing cover to vertical column. Retain screws.
6. Lift Cross Arm Bearing cover off bearing assembly.

7. Being careful not to damage any switch or indicator terminals, set bearing cover across Cross Arm with switches and indicators facing up.
8. To completely remove Cross Arm Bearing cover, loosen it as described above, then tag and disconnect each cable harness.



Cross Arm Bearing Cover Removal

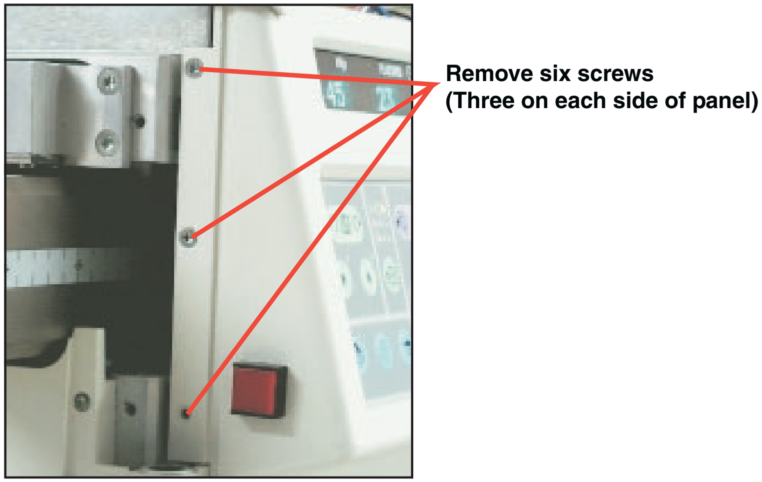
Control Panels

There are two identical Control Panels on the Vertical Column. Each Control Panel holds a Key/Display assembly, and a Vacuum Fluorescent Display (VFD). Follow these steps to remove either Control Panel cover:

1. Disconnect Workstation power cord from AC outlet.
2. Remove Cross Arm Bearing cover.
3. Loosen six screws that secure Control Panel cover to Vertical Column.

4. Carefully pull Control Panel away from Vertical Column.
5. Disconnect and tag all wires.

Note: *Display and Keypad in Control Panel are held in place by screws and are both field replaceable Use Loctite 454 and accelerator when reassembling.*



Control Panel Cover

Circuit Breakers and Fuses

This section describes how to access and replace field serviceable circuit breakers and fuses in the C-Arm.

Replacement procedures are not provided for fuses that mount in familiar snap-in or cartridge holders on printed circuit boards or electronic modules. Capacity and physical size information for these devices is included, however.

Note: *Some protective devices on PCBs are soldered in place are therefore not field replaceable*

Assemblies With No Breakers or Fuses

There are no field replaceable circuit breakers or fuses in the following assemblies:

C-Arm Assemblies That Contain No Field Replaceable Fuses or Circuit Breakers	
Backplane (879364)	Generator Driver PCB (878908)
Battery Charger (880306)	Handswitch (901144)
Battery Packs (900589)	Heat Pipe (879557 or 880717)
CCD Camera (879126 or 879127)	High Voltage Supply Regulator PCB (878729)
Collimator (880391 or 880430)	High Voltage Tank (900987)
Column Lift (901166)	IGBT Fan (881200)
Column Lift Power Supply (901177)	Image Intensifier (901226 or 901083)
Control Panel Processor PCB (878488)	Image Intensifier Power Supply (901180)
Control Panel Processor I/O PCB (880324)	Lift Up Switch and Cable (879031)
Fan B2 (879970)	Lift Down Switch and Cable (879395)
Fast Stop Switch (879407)	X-ray Controller PCB (879805)
Filament Driver PCB (879722)	X-ray On Switch Assembly (879422)
Fluoro Functions PCB (879101)	X-ray Tube (901318)
Footswitch (881060)	X-ray Tube Fan B3 (881220 or 881219)

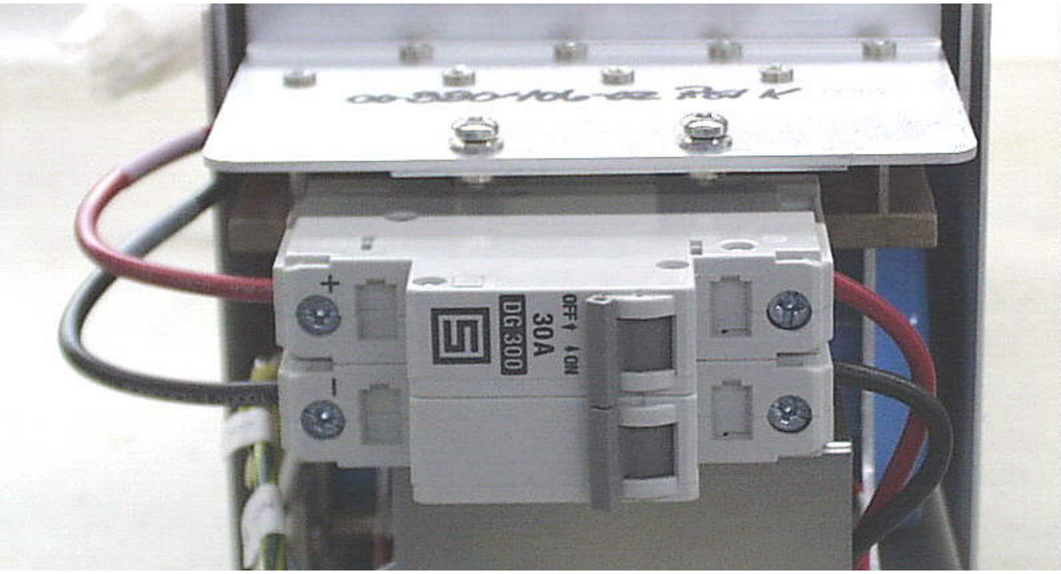
Capacitor/Power Module

***WARNING**: Touching the Capacitor/Power Module is very dangerous because of the high voltages present on the battery cables and high voltages on the capacitor bus bars. The Capacitor/Power Module is also dangerously close to the High Voltage Tank and High Voltage cables. You must assume that lethal voltages are always present at ALL these points EVEN WHEN THE SYSTEM IS POWERED DOWN. Failure to read and follow all directions may result in death or serious injury from electric shock*

There are three cartridge type fuses and one circuit breaker in the Capacitor/Power module.

Circuit Breaker CB1

CB1 is a dual-pole, energy-limiting circuit breaker that mounts on the bottom of the Capacitor/Power Module (see *Capacitor/Power Module* section, later in this chapter).



Remove Capacitor/Power Module to Access Circuit Breaker CB1

You cannot normally see CB1 without using a mirror because it is located on the bottom of the Capacitor/Power Module an inch or so off the floor. You can locate and operate CB1 by feeling underneath the Capacitor/Power Module. Open the breaker by positioning the handle toward the rear of the C-Arm. Close the breaker by moving the handle toward the front of the C-Arm. The breaker handle goes to the middle position when the breaker trips. Reset CB1 by moving the handle to the open position and then to the closed position.

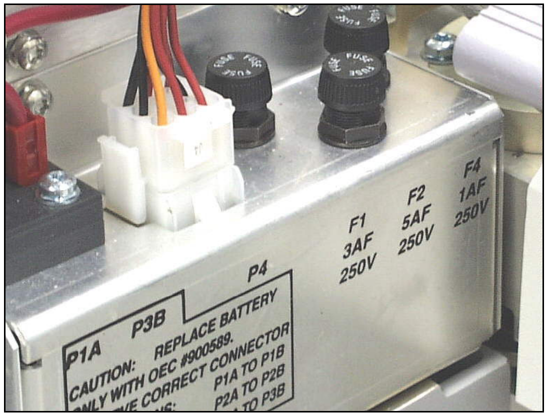
WARNING: *Do not attempt to replace CB1 without powering down the system, disconnecting the Battery Packs, and discharging any residual charge on the high energy capacitors. Failure to take these safety measures may result in death or serious injury from electric shock.*

CB1 protects the battery packs from overload conditions such as a shorted high-energy capacitor or a short across the capacitor bus bars. Replace CB1 if it continually trips without identifiable cause, or if it cannot be reset. Follow these steps to replace CB1:

1. Disconnect Workstation power plug from AC outlet.
2. Remove C-Arm's Right Side cover.
3. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect battery cables from P1A and P3B on Capacitor/Power module. (Refer to Capacitor/Power module replacement procedure in this chapter for details.)
4. Locate two battery cables just above P1A and P3B. These two cables have blue connectors that connect to each other. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect the cables from each other.
5. USING GREAT CARE TO AVOID ELECTRIC SHOCK, connect a current-limiting resistor (300k or so) across Capacitor/Power module busbars to discharge high energy capacitors inside Capacitor/Power module. (Refer to Capacitor/Power module replacement procedure in this chapter for details.)
6. Remove Capacitor/Power module from C-Arm chassis. Follow procedure described under ***Electrical and Electronic Assemblies*** later in this chapter.
7. Remove attaching hardware that secures CB1 to Capacitor/Power module. Retain attaching hardware for reuse.
8. Disconnect and tag wires from CB1.
9. Withdraw CB1 from Capacitor/Power module.
10. Connect wires you removed in step 8 to replacement circuit breaker.
11. Mount replacement circuit breaker in Capacitor/Power module. Secure replacement breaker with attaching hardware you removed in step 6.
12. Secure Capacitor/Power Module to C-Arm chassis.
13. Reconnect battery cables you detached in steps 3 and 4. Make sure all wiring is correctly routed through cable strapping as it was prior to disassembly.
14. Connect Workstation power cord to AC outlet.
15. Power up system and check for proper operation.
16. Install all covers before returning C-Arm to service.

Fuses F1, F2, and F4

The three Capacitor/Power Module fuses F1, F2, and F3 are 250-Volt, 1/4 by 1-1/4 inch, fast blow glass cartridge types. You can examine any of these fuses by unscrewing the appropriate fuse cap and withdrawing the suspect fuse.


F1
3AF
250V
F2
5AF
250V
F4
1AF
250V
P4
P1A
P3B
CAUTION: REPLACE BATTERY
ONLY WITH OEC #900589.
CORRECT CONNECTOR
P1A TO P1B
P2A TO P2B
TO P3B

Fuses F1, F2, and F4

Always use an ohmmeter to check a fuse for continuity. A fuse that passes visual inspection may be faulty. Replace any defective fuse with another fuse of the same type, capacity, and physical size. If a fuse checks OK with a meter but still looks burned or otherwise damaged, replace it anyway.

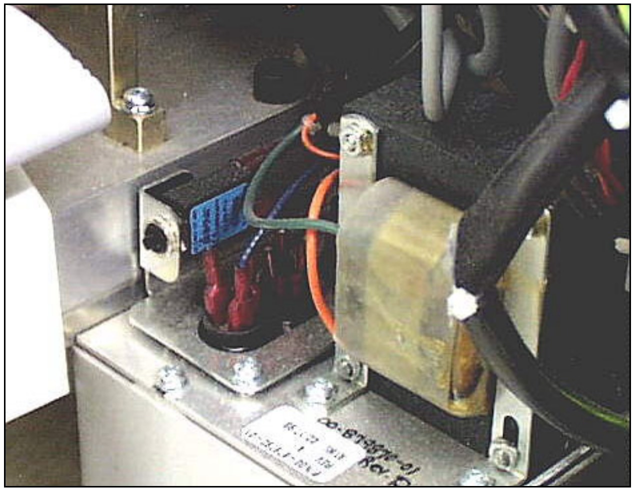
F1 protects the output of the Battery Charger. F1 is rated at 3 Amps.

F2 protects the CAP_POS capacitor charging line to the Filament Driver PCB. F2 is rated at 5 Amps.

F4 protects the BAT_POS_F4 battery charge sense line to the Filament Driver PCB. F4 is rated at 1 Amp.

Stator Capacitor/Transformer Assembly

CB2 mounts on the top side of the Stator Capacitor/Transformer Assembly as shown in the following illustration.



Circuit Breaker CB2

CB2 is a 1-Amp breaker that protects the XFMR_115VAC line to Stator Transformer T3. Use the following procedure to replace CB2:

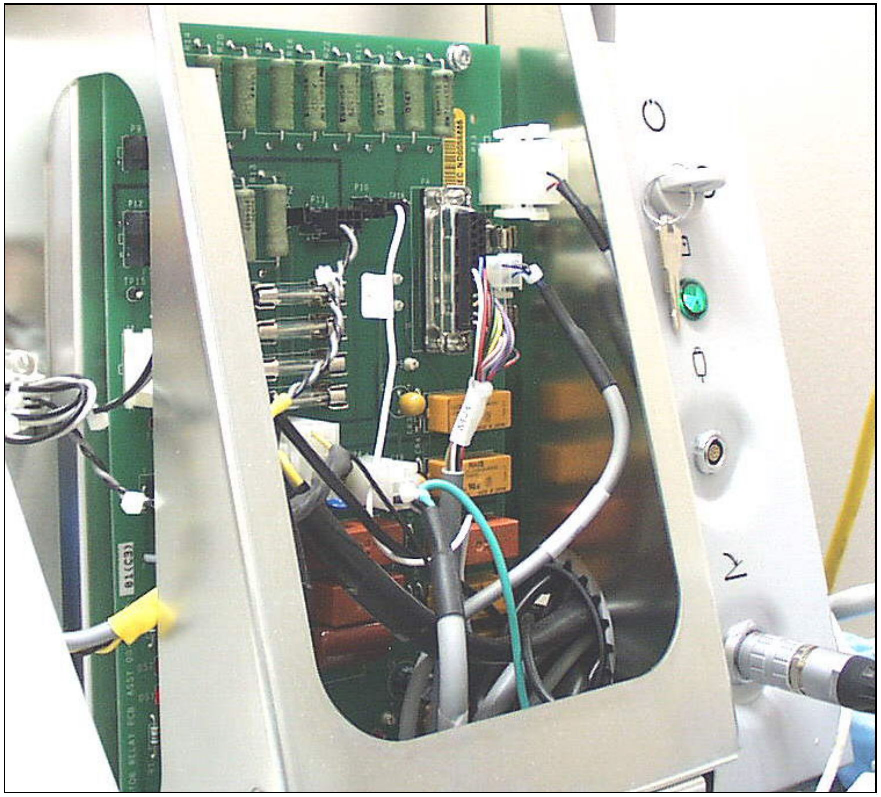
1. Disconnect Workstation power plug from AC source.
2. Remove C-Arm's Left Side cover.
3. Remove attaching hardware that secures CB2 to Stator Capacitor/Transformer module. Retain attaching hardware for reuse.
4. Withdraw CB2 from its mounting spot.
5. Disconnect and tag wires from CB2.
6. Connect wires you removed in step 4 to replacement circuit breaker.
7. Mount replacement circuit breaker on Stator Capacitor/Transformer module. Secure replacement breaker with attaching hardware you removed in step 3.

8. Connect Workstation power cord to AC outlet.
9. Power up system and check for proper operation.

Power Motor Relay PCB

Refer to the following illustration and table for information on circuit breakers and fuses on the Power Motor Relay PCB, which is located under the C-Arm's front cover.

WARNING: *Do not replace any device on the Power Motor Relay PCB without first powering down the system. Failure to observe this precaution may result in potentially fatal electric shock or burns, and may also cause equipment damage.*



Power Motor Relay PCB

Note: *All fuses listed in the following table are field replaceable 250-Volt, 1/4 x 1-1/4-inch, tubular Slo Blo unless otherwise indicated.*

Power Motor Relay PCB Fuses

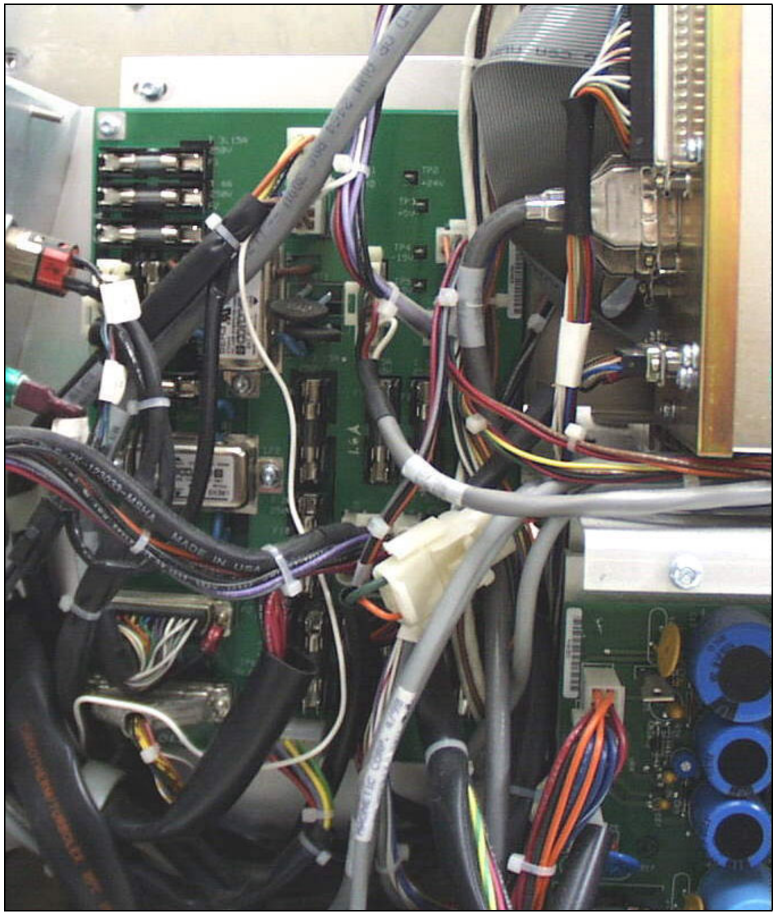
Ref Des	Capacity	Part Number	Purpose
CB1	2A	55-700463-00	SPST 250 VAC PC-mounted breaker. NOT FIELD REPLACEABLE. Trips if stator circuit sticks in 120 VAC (start) mode longer than 15 seconds.
F1	.25A	67-132350-00	Protects the 36 VDC line to the keyswitch/column lift circuitry. This is not a Slo Blo fuse.
F2	2A	67-135420-00	Protects spare +12-Volt line at P12 pin 4
F3	2A	67-135420-00	Protects +12-Volt line to IGBT fan B1
F4	1A	67-135410-00	Protects +12-Volt lines at P11 pins 3 and 4. Pin 3 supplies power to cooling fan for the X-ray tube
F5	2A	67-135420-00	Protects the CCD camera cooler power.
F6	1A	67-135410-00	Protects spare +5 Volts at P11 pins 1 and 2.
F7	.5A	67-132350-00	Protects +5 Volts supplied by P9 pin 1 to the Handswitch.
R2	10J	55-199832-00	Fusible resistor. NOT FIELD REPLACEABLE. Protects relay K1 contacts from switching transients.
R4	10J	55-199832-00	Fusible resistor. NOT FIELD REPLACEABLE. Protects relay K2 contacts from switching transients.
R11	10J	55-199832-00	Fusible resistor. NOT FIELD REPLACEABLE. Protects relay K15 contacts from switching transients.

Power Signal Interface PCB

Many of the field replaceable fuses associated with C-Arm circuitry reside on the Power Signal Interface PCB. Refer to the following illustration and table for details.

WARNING: *Don't replace any fuse on the Power Signal Interface PCB without first powering down the system. Failure to observe this precaution may result in potentially fatal electric shock or burns, and may also cause equipment damage.*

Note: *115 VAC power from Workstation Interconnect Cable plug P1 enters Power/Signal Interface PCB on P5.*



Power Signal Interface PCB

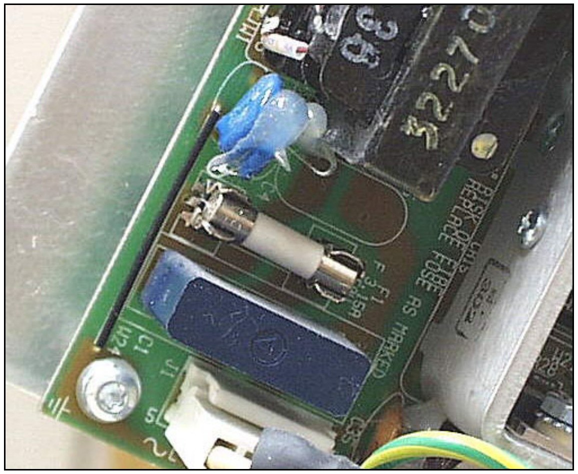
Note: *All fuses listed in the following table are 250-Volt 5 x 20mm (¼ x1¼ inch) tubular Slo Blo unless otherwise indicated.*

Power Signal Interface PCB Fuses			
Ref Des	**Capacity**	**Part Number**	**Purpose**
F1	3.15A	55-500345-00	Protects the 115VAC_RTN_MTR line from F2 to Power Supply PS1 (P4-11). This fuse also protects the 115VAC_RTN_MTR line that goes to Power Supply PS2 (P9-14).
F2	4A	55-500346-00	Protects the 115VAC_RTN line (P5-1) that supplies AC power from the Workstation (P5-1) to the Power/Motor Relay PCB (P8-4, 5, 12, and 13). F2 also protects the 115VAC_RTN_MTR line to fuse F1.
F3	6.3A	55-500351-00	Protects the 115VAC_RTN line that travels from the Workstation (P5-1) through LF1 to the Battery Charger (P3-3).
F4	4A	55-500346-00	Protects the 115VAC_PH line from the Workstation (P5-4) that supplies AC power to the Power/Motor Relay PCB (P8-1 and 2).
F5	6.3A	55-500351-00	Protects the 115VAC_PH line from the Workstation (P5-4) that supplies AC power through LF1 to the Battery Charger (P3-4).
F6	3.15A	55-500345-00	Protects the 115VAC_PH_SW line (P8-9) from the Power/Motor Relay PCB. This is switched AC power that travels through LF2 to Power Supply PS1 (P4-12). This power also goes to PS2 via F10 and P9-7.
F7	1.6A	55-500354-00	Protects the -15V_PS1 line (P4-9) from Power Supply PS1 to the Backplane (P11-2, 3) and to the Generator Driver PCB (P10-3).
F8	1.6A	55-500354-00	Protects the +15V_PS1 line (P4-6) from Power Supply PS1 to the Backplane (P11-1, 5). Also supplies +15 Volts to the Generator Driver PCB (P10-1).
F9	5A	55-500347-00	Protects the +5V_PS1 line (P4-1, 2, 3) from Power Supply PS1 to the Backplane (P11-6, 7). This line also supplies +5 Volts to the Generator Driver PCB (P10-4).

Power Signal Interface PCB Fuses			
Ref Des	**Capacity**	**Part Number**	**Purpose**
F10	2.0A	55-500344-00	Protects the 115VAC_PH_PS2 line (P9-7) that supplies AC power from fuse F6 to Power Supply PS2.
F11	3.15A	55-500345-00	Protects the +24V_PS2 line (P9-12) from Power Supply PS2. This line supplies +24 Volts to the Power/Motor Relay PCB (P8-8).
F12	3.15	55-500345-00	Protects the +5V_PS1 line (P4-1, 2, 3) that supplies +5 Volts from Power Supply PS1 to the Control Panel Processor I/O PCB (P6-1, 2, 3).
F13	2.0A	55-500344-00	Protects the +6.0_PS2 line (P9-1, 8) that supplies +6.0 Volts from Power Supply PS2 to the CCD Camera (P7-1, 5).
F14	1.0A	55-500343-00	Protects the -6.0_PS2 line (P9-2, 9) that supplies -6.0 Volts from Power Supply PS2 to the CCD Camera (P7-2, 6).
F15	0.8A	55-500350-00	F15 is a 0.8A fuse that protects the +14V_PS2 line from Power Supply PS2 (P9-3) to the CCD camera (P7-3).
F16	0.5A	55-500349-00	Protects the -14V_PS2 line from Power Supply PS2 (P9-10) to the CCD camera (P7-7).

Power Supply PS1

Power Supply PS1 has only one field replaceable fuse, which appears in the following illustration.

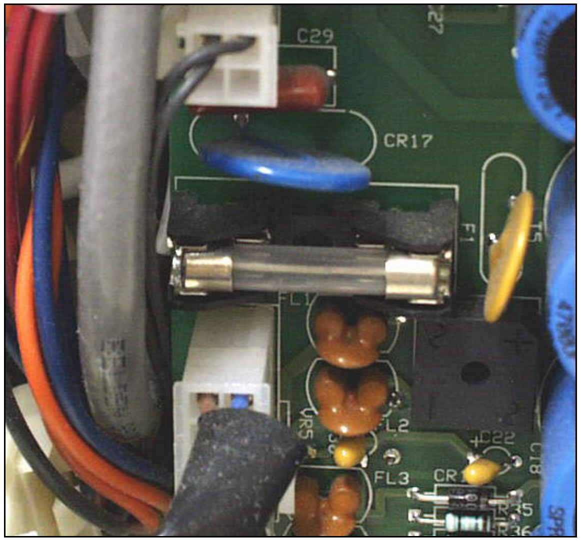


Fuse F1 on Power Supply PS1

Fuse F1 is a 3.15 Amp fast blow fuse that protects PS1’s internal circuitry only. F1 does not blow if PS1’s outputs are shorted or overloaded.

Power Supply PS2

Power Supply PS2 has one field replaceable fuse as shown in the following illustration.



Fuse F1 on Power Supply PS2

F1 is a 1.0 Amp fuse that protects the primary winding on externally mounted power transformer T2.

Important Safety Message

***DANGER**: Read the following information carefully. Failure to do so could result in death, personal injury, or equipment damage.*

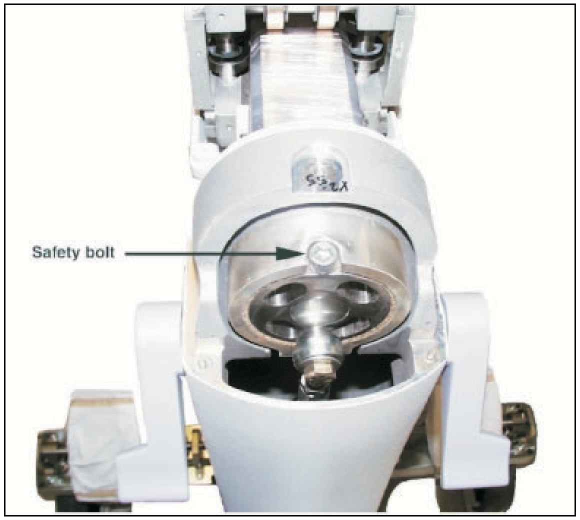
***Note**: The following information does not apply to the Super C, which does not have an L-Arm.*

A gas-shock-dampened spring regulates L-Arm rotational movement in a Standard nine-inch or 12-inch system. This makes it is possible to manually position the balanced L-Arm in any convenient position and have the L-Arm and attached C remain stationary when you remove your hand.

When you replace the X-ray Tube or the Image Intensifier, you disturb the balanced condition of the L-Arm and the attached C, and you must exercise special care to avoid inadvertent movement of the L-Arm due to the unbalanced condition. **It is possible for the unbalanced L-Arm to rotate very quickly and very forcefully, causing personal injury and equipment damage.**

Follow these steps to secure the L-Arm **before performing related maintenance**:

1. Obtain 3/8-16 x 3/4” safety bolt.
2. Remove L-Arm cover.
3. Position L-Arm in normal vertical position with Flip Flop assembly holding C-Arm vertically. Set Flip Flop brake, but do not set L-Arm brake at this time.
4. Rotate L-Arm slightly until hole for safety bolt becomes visible. Install and secure safety bolt as shown in the following illustration. Secure the L-Arm brake.



C-Arm Safety Bolt

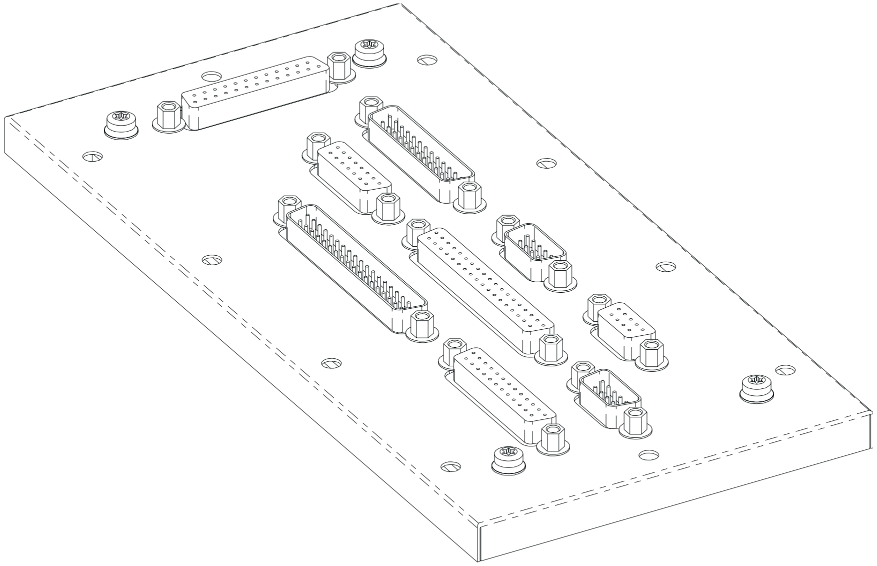
6. Remove the suspect Image Intensifier or X-ray tube.
7. Install the replacement Image Intensifier or X-ray tube.
8. Remove and stow the safety bolt.
9. Check the C-Arm for proper operation and return it to service.

Electrical and Electronic Assemblies

This section provides replacement procedures for most electrical and electronic assemblies in the C-Arm.

Backplane

The Backplane mounts at the rear of the C-Arm card rack, where it provides an edge connector for the Fluoro Functions PCB, X-ray Controller PCB, and High Voltage Supply Regulator PCB. As the following illustration shows, there are number of connectors on the opposite side of the Backplane as well. Please refer to the Power Distribution section of this manual for more details.



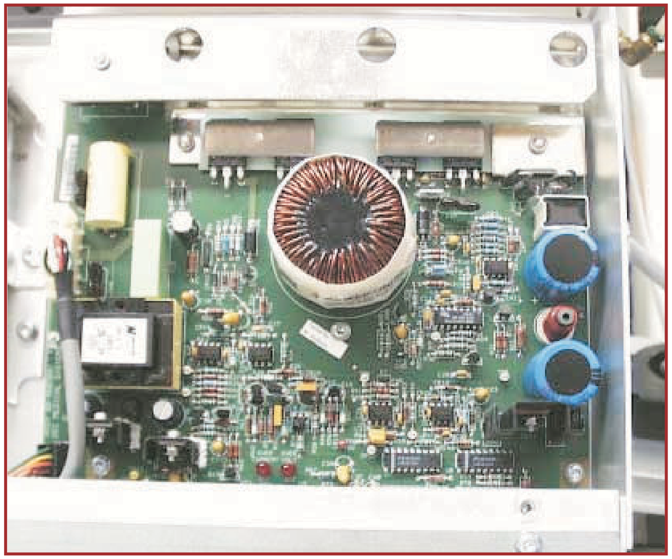
Backplane

Follow these steps to replace the Backplane:

1. Turn off Workstation power and disconnect Workstation's AC plug from facility's AC outlet.
2. Remove C-Arm's Rear Cover.
3. Remove card rack's rear metal cover to expose PCBs inside rack. Retain screws.
4. Remove all three circuit card assemblies from card rack. Note position of each PCB.
5. Tag and unplug all connectors and ground wires from Backplane assembly.
6. Remove torx screws that secure Backplane assembly to card rack. Retain screws.
7. Remove Backplane assembly from card rack.
8. Install Backplane assembly to card rack assembly. Secure with screws you removed in step 6.
9. Install all connectors and ground wires you removed in step 5.
10. Install the three PCBs in card rack you removed in step 4.
11. Install card rack's rear metal cover you removed in step 3.
12. Power up system and check for proper operation.
13. If system functions correctly, install C-Arm's Rear Cover.

Battery Charger

The Battery Charger PCB mounts at the rear of the C-Arm under the Rear Cover and Component Tray Cover as shown in the following illustration. The following procedure explains how to replace the Battery Charger.



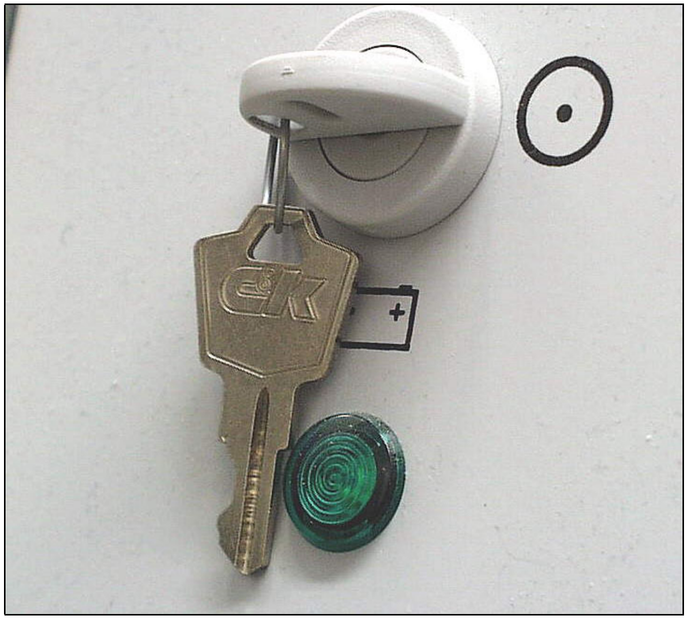
Battery Charger PCB

1. Turn off Workstation and remove Workstation’s AC plug from facility outlet.
2. Remove Rear cover from C-Arm.
3. Remove Component Tray cover from C-Arm
4. Remove connectors from P1, P2, and P3 on the Battery Charger PCB.
5. Remove two torx screws that secure bottom edge of Battery Charger PCB to C-Arm chassis. Retain screws.

6. Remove three nuts that secure Battery Charger heat sink to C-Arm chassis. Retain nuts.
7. Carefully lift Battery Charger PCB from studs that support heatsink.
8. Inspect replacement Battery Charger PCB for missing components or obvious damage.
9. Install replacement Battery Charger PCB onto mounting studs.
10. Install nuts removed in step 6 on mounting studs. Finger tighten only.
11. Install torx screws removed in step 5 through mounting holes at bottom of Battery Charger PCB.
12. Secure all mounting hardware
13. Connect wires removed in step 4 to P1, P2, and P3 on replacement Battery Charger PCB.
14. Adjust Battery Charger output procedure in Calibration chapter.
15. Install Component Tray cover removed in step 3.
16. Install Rear cover on C-Arm.

Battery Charger Indicator Lamp

The Battery Charger Indicator Lamp shown below is located on the C-Arm Power Panel near the Keyswitch. This is a 120 VAC neon lamp that glows any time AC power is applied to the C-Arm through the Interconnect Cable.

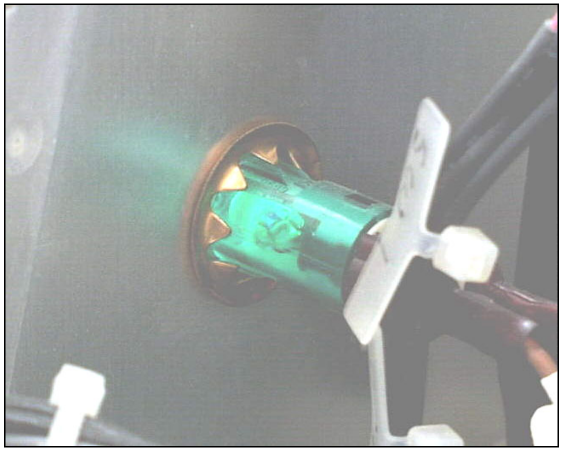


Battery Charger Indicator Lamp

Use the following procedure to replace the lamp.

1. Turn off Workstation and remove Workstation's AC power plug from AC outlet.
2. Remove Left Side cover from C-Arm.
3. Remove two screws that secure Power Panel cover.

4. Open Power Panel Open cover to access Power Panel Interior.
5. Disconnect the two spade connectors from the neon lamp assembly.
6. Use flat-bladed screwdriver to gently pry off metal ring that secures lamp assembly to Power Panel. Refer to the following illustration for additional details.

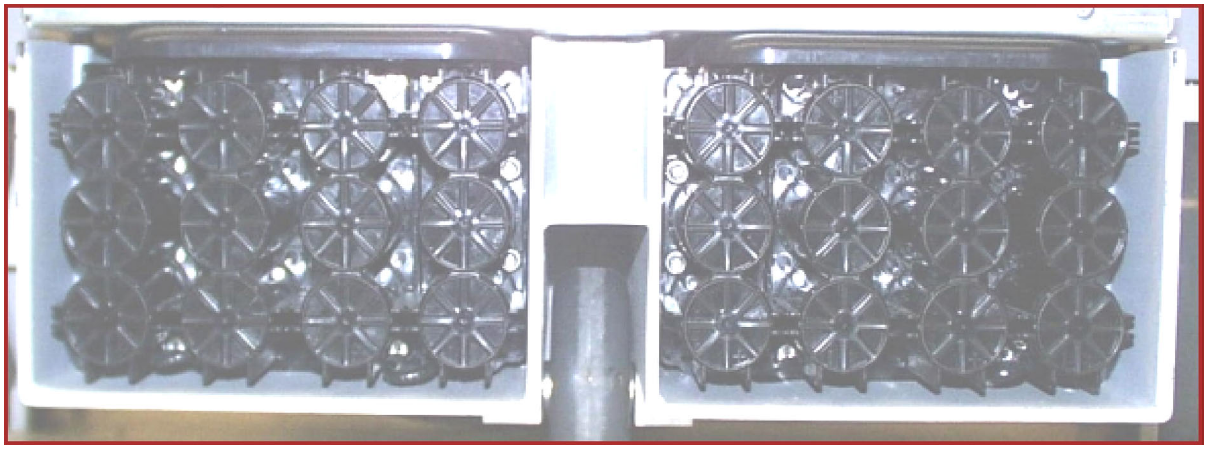


Indicator Lamp Mounting Details

7. Remove the indicator lamp from the front of the Power Panel.
8. Install replacement indicator lamp through

Battery Packs

The two identical Battery Packs mount in cavities at the base of the C-Arm as shown below:



Battery Packs

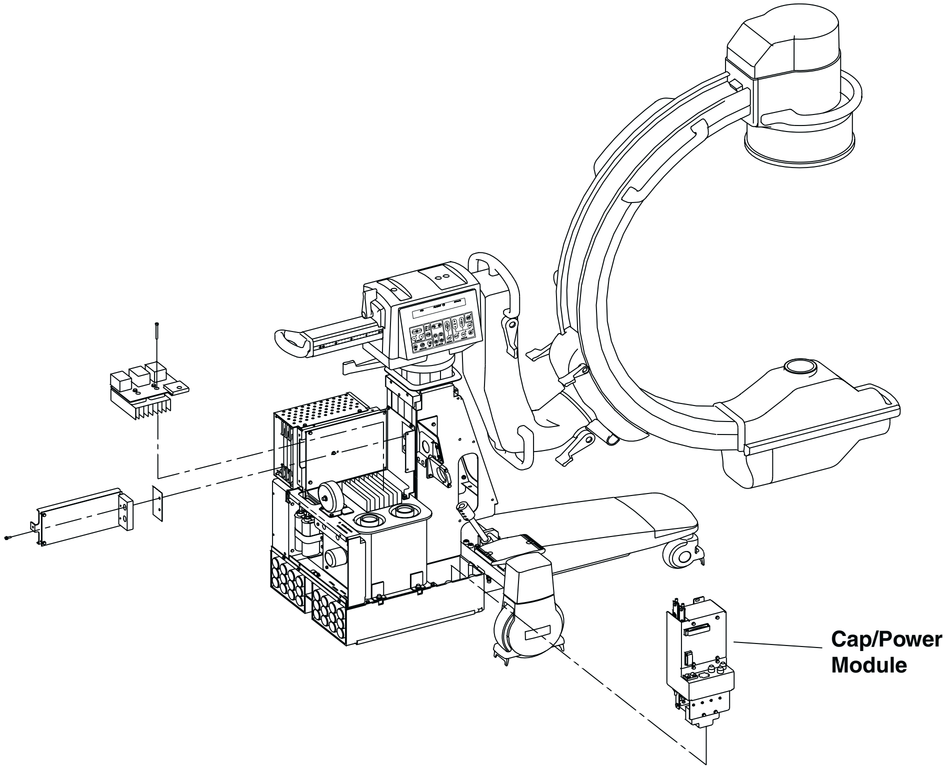
Follow this procedure to replace the Battery Packs:

1. Power down the system and remove the Workstation’s power plug from the facility’s AC outlet.
2. Disconnect black Battery Pack wire terminal from P1A on the Capacitor/Power module.
3. Disconnect red Battery Pack wire terminal from P3B on the Capacitor/Power module.
4. Near the Capacitor/Power module, you will notice a red and black wire connected together, and secured by a plastic strap. Notice also that both of these wires have blue terminals. Pull these wires from under the plastic strap and disconnect them from each other.
5. Stuff all four disconnected wires back into the battery compartments.
6. Remove the two U-shaped spacers that hold the Battery Packs in each battery compartment.

7. Lifting it slightly, withdraw the left Battery Pack from its battery compartment. Remove the right Battery Pack in a similar manner.
8. Inspect each replacement Battery Pack for missing components or obvious damage.
9. Connect a temporary four-foot length of non-conductive fish tape to the wires on each replacement Battery Pack.
10. Set each Battery Pack on the floor near the rear of the C-Arm and route each fish tape up through the appropriate access hole at the rear each battery compartment.
11. While pulling on the fish tape, gently push the left Battery Pack into place in its battery compartment. Do the same thing with the right Battery Pack.
12. Connect the red wire with the blue terminal and black wire with the blue terminal together. Stow the connected wires under the plastic strap identified in step 4.
13. Connect the red wire's terminal to P3B on the Capacitor/Power module.
14. Connect the black wire's terminal to P1A on the Capacitor/Power module.
15. Connect the Workstation's power cord to facility's AC outlet. Allow replacement batteries to charge for 24 hours and then check system for proper operation.

Capacitor/Power Module

The Capacitor/Power Module mounts in the front of and above the battery tray next to the High Voltage Tank as shown in the following illustration.



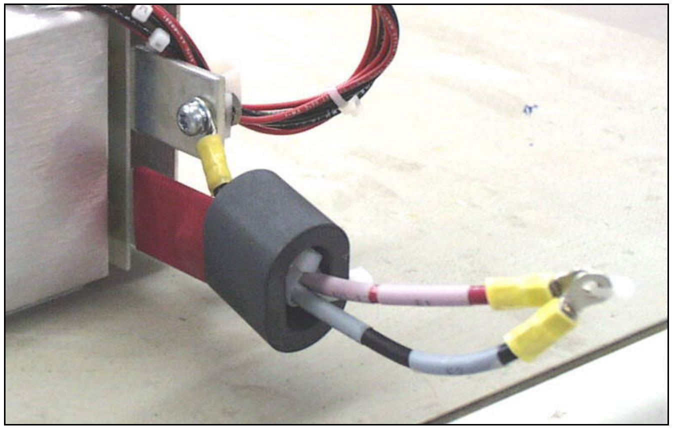
Capacitor/Power Module

Use the following procedure to replace the Capacitor/Power Module:

WARNING: ***Touching the Capacitor/Power Module is very dangerous because of the high voltages present on the battery cables and high voltages on the capacitor bus bars. The Capacitor/Power Module is also dangerously close to the High Voltage Tank and High Voltage cables, which are also a source of high voltage. You must always assume that lethal voltages are present at ALL these points EVEN WHEN THE SYSTEM IS POWERED DOWN. Failure to read and follow all directions may result in death or serious injury from electric shock.***

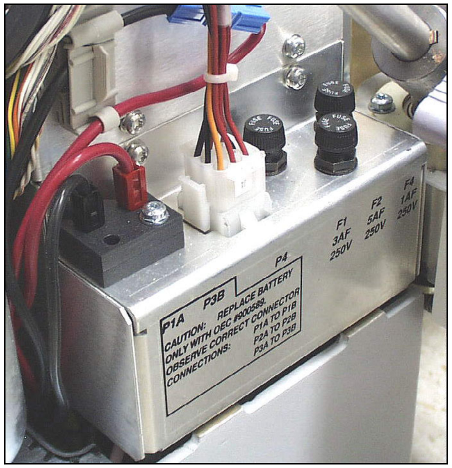
1. Turn off Workstation and disconnect its AC power plug from the AC outlet.
2. Disconnect Interconnect cable from C-Arm.
3. Remove Front Cover from C-Arm and slide it forward over the High Voltage cable.
4. Remove Right Side cover from C-Arm.
5. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect battery cables from P1A and P3B on Capacitor/Power Module.
6. Locate two battery cables just above P1A and P3B. These two cables have blue connectors that connect to each other. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect the cables from each other and move them out of the cable restraint on the Capacitor/Power module.
7. USING GREAT CARE TO AVOID ELECTRIC SHOCK, connect a current-limiting resistor (300K or so) across bus bars to discharge high energy capacitors inside Capacitor/Power module.

Note: *Busbars on an installed Capacitor/Power Module are difficult to see. The following illustration shows the busbars on an uninstalled module. The two free wires on the ends of the busbars connect to terminals on the IGBT Snubber PCB. Be careful not to lose or damage the transient-suppressing toroid that surrounds the two wires.*



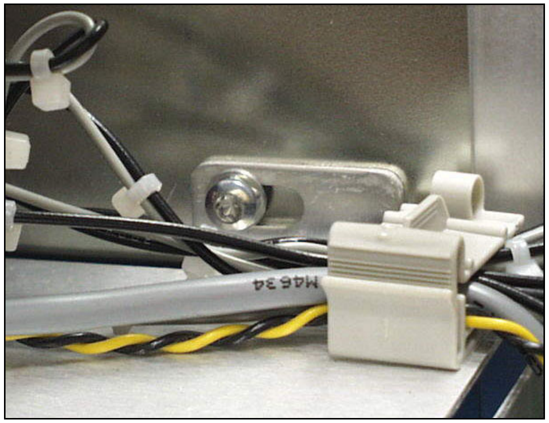
Busbars on Capacitor/Power Module

8. Disconnect multi-pin plug P4 from J4.
9. Free all wiring from cable restraints on the Capacitor/Power module and move the wiring out of the way.
10. Disconnect busbar wiring from connectors on IGBT Snubber PCB. Be careful not to damage heat shrink on positive busbar.


P1A
P3B
P4
CAUTION: REPLACE BATTERY
ONLY WITH OEC #900589.
OBSERVE CORRECT CONNECTOR
CONNECTIONS: P1A TO P1B
P2A TO P2B
P3A TO P3B
F1
3AF
250V
F2
5AF
250V
F4
1AF
250V
FUSE

Capacitor/Power Module Connectors

11. Remove the single screw at the top of the Capacitor/Power module that secures it to the Vertical Column.



Capacitor/Power Module Mounting Screw

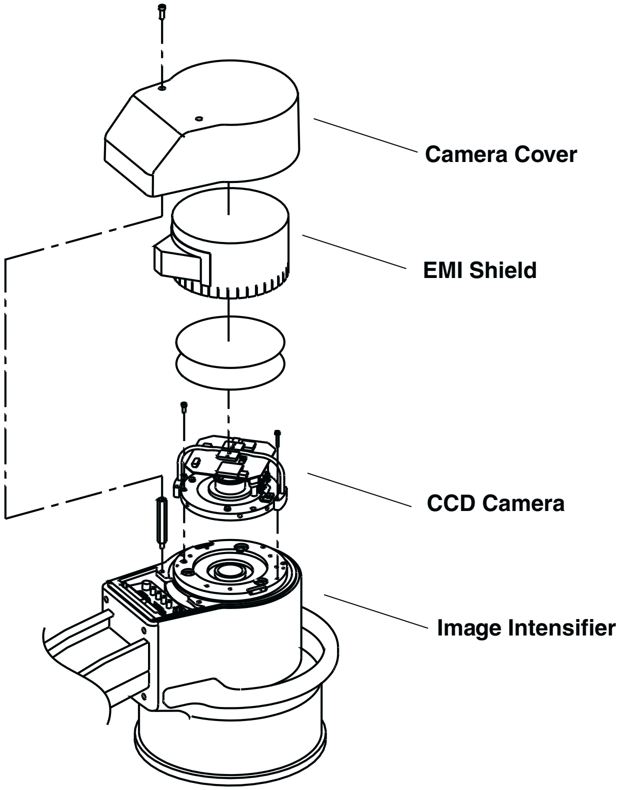
12. Remove the Capacitor/Power Module from the C-Arm.

CCD Camera and Cooler

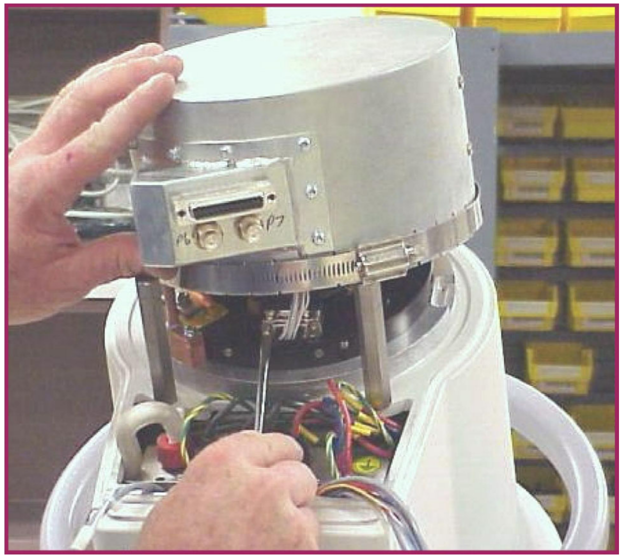
The CCD camera mounts on the output phosphor end of the Image Intensifier as shown in the following illustrations.

Follow these steps to replace the CCD Camera assembly:

1. Turn off Workstation and disconnect it from the AC outlet.
2. Place the C-Am in a horizontal position so CCD camera is easy to access.
3. Remove two screws that secure Camera Cover.
4. Disconnect 2 BNC connectors and 1 sub-D connector from the EMI Shield.
5. Use a standard screwdriver to loosen the clamp that secures the EMI Shield as shown next.

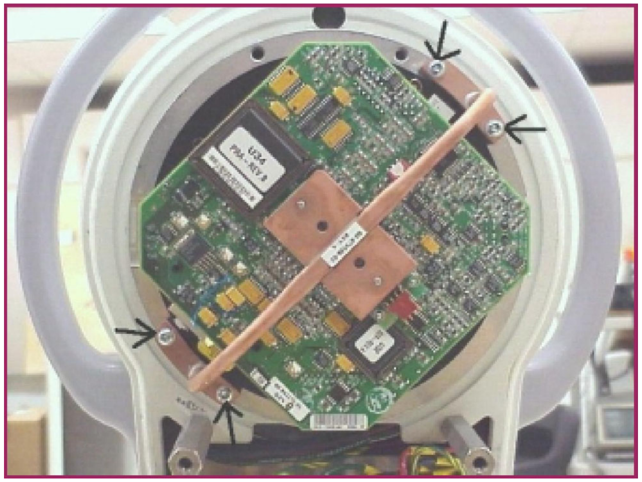

Camera Cover
EMI Shield
CCD Camera
Image Intensifier

CCD Camera Location



EMI Shield Removal

6. Lift the EMI Shield up and disconnect the wires that run from the EMI Shield to the Camera.
7. Remove four screws that secure Thermoelectric Cooler to camera. Screws appear in next illustration.



Thermoelectric Cooler Mounting Screws

8. Remove three screws (black mount) that secure CCD Camera.
9. Reassemble in reverse order and check Camera alignment.

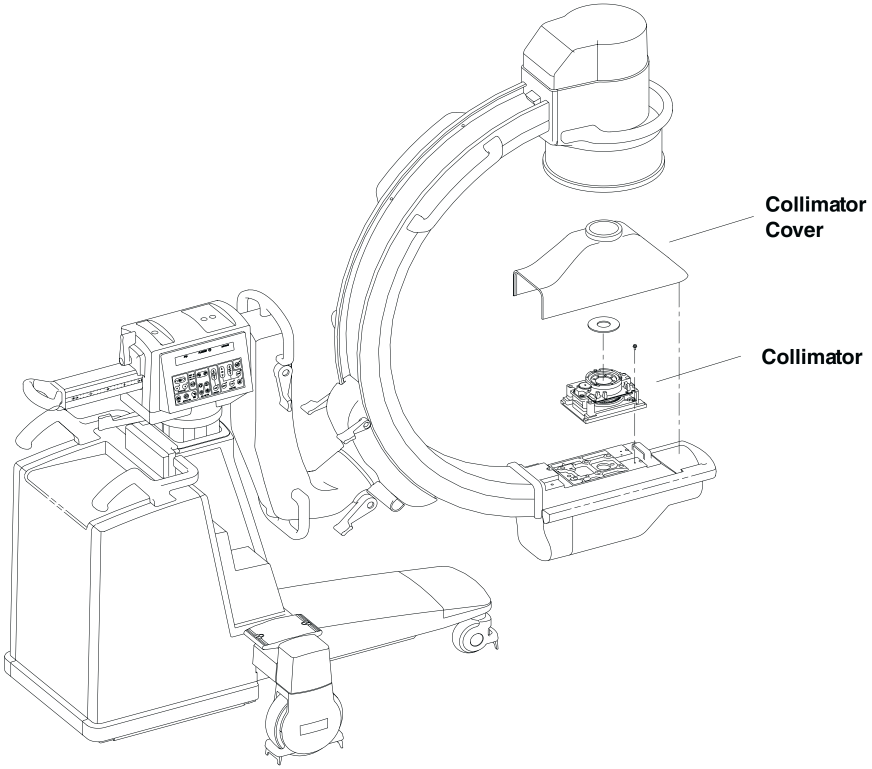
Collimator

The Collimator mounts over the X-ray tube aperture as shown in the following illustration.

Follow these steps to replace the Collimator:

1. Turn off Workstation power switch in the OFF position.
2. Place the C-arm in a horizontal position so the Collimator is easy to access.
3. Remove the tape from the back seam of the Collimator Cover.
4. Remove the Collimator Cover (2 screws).
5. Disconnect connector A17J1 on the Collimator.

6. Remove four screws that secure the Collimator and remove the Collimator.
7. Reassemble in reverse order.
8. Check the beam alignment and adjust Z and X axis of the Collimator if necessary.



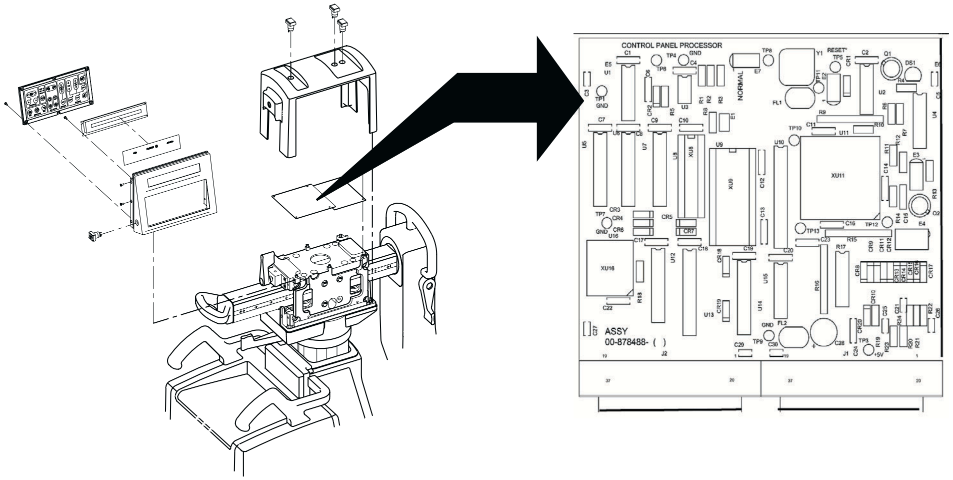
Collimator Location

Control Panel Processor PCB

The Control Panel Processor resides under the Cross Arm Bearing cover as shown next.

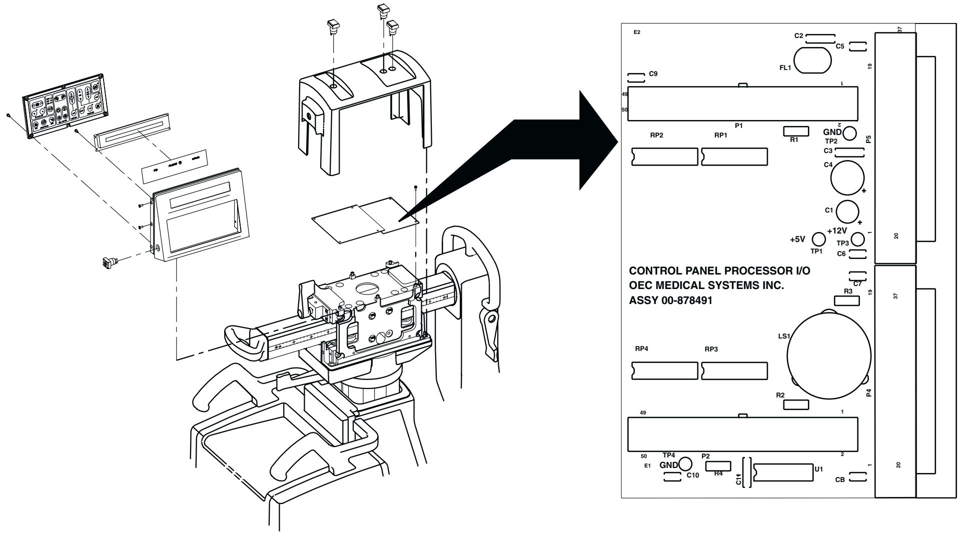
Follow these steps to remove the Control Panel Processor PCB:

1. Turn off the Workstation and unplug it from the AC outlet.
2. Remove Cross Arm Bearing cover as described in the ***Equipment Covers*** section of this chapter.
3. Disconnect and tag wiring from the CPP I/O PCB.
4. Remove two screws that secure the CPP/IO PCB to the chassis.
5. Remove the CPP I/O PCB from its connection to the CPP PCB.
6. Remove the top of the EMI shield from the CPP PCB (friction fit).
7. Disconnect wiring from connectors and tag each wire.
8. Remove four screws that secure the CPP PCB to the chassis.
9. Lift the CPP PCB out of the bottom half of the EMI shield.


CONTROL PANEL PROCESSOR
NORMAL
RESET
ASSY
00-878488- ( )

Control Panel Processor PCB

Control Panel Processor I/O PCB

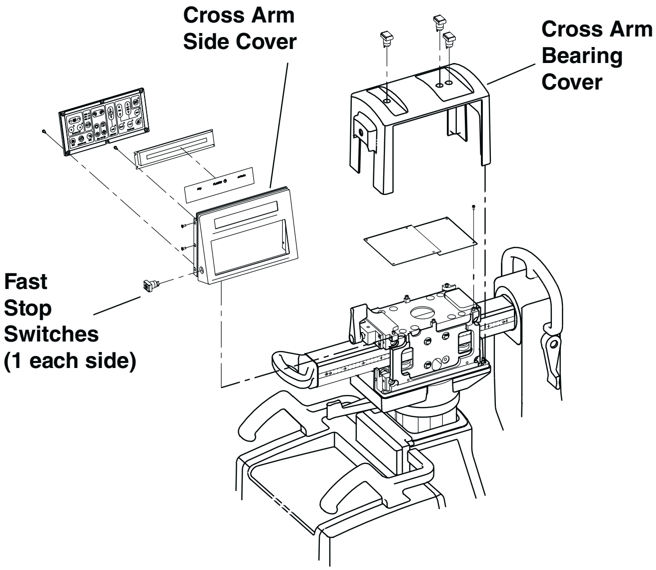

E2
C2
C5
FL1
C9
49
50
1
P1
2
RP2
RP1
R1
GND
TP2
P5
C3
C4
C1
+12V
+5V
TP1
TP3
C6
CONTROL PANEL PROCESSOR I/O
OEC MEDICAL SYSTEMS INC.
ASSY 00-878491
C7
R3
LS1
RP4
RP3
R2
P4
TP4
GND
E1
C10
P2
R4
C11
U1
CB
37
19
20

Control Panel Processor I/O PCB

Follow these steps to replace the Control Panel Processor I/O PCB:

1. Turn off Workstation and disconnect its power plug from the AC outlet.
2. Remove Cross Arm Bearing cover as described in the ***Equipment Covers*** section of this chapter.
3. Disconnect wires from connectors on the CPP I/O PCB. Tag each wire
4. Remove two screws that secure the CPP I/O PCB to the chassis.
5. Remove the CPP I/O PCB from its connection to the CPP PCB.

Fast Stop Switches


Cross Arm Side Cover
Cross Arm Bearing Cover
Fast Stop Switches (1 each side)

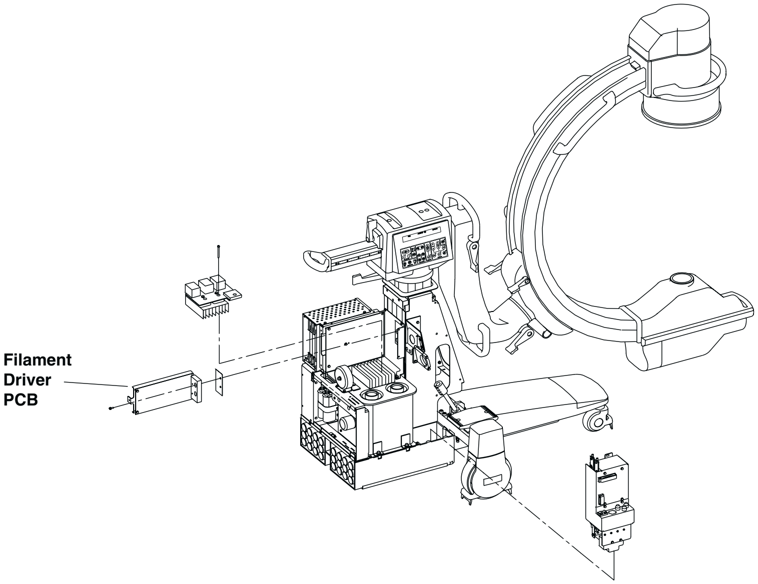
Fast Stop Switches

Follow these steps to replace a suspect Fast Stop switch.

1. Turn Workstation off and disconnect its AC power plug from the AC outlet.
2. Remove Cross Arm Bearing cover as described in the ***Equipment Covers*** section of this chapter.
5. Remove three screws from each end of the Control Panel that houses the suspect Fast Stop switch (six screws total).
6. Remove loosened Control Panel.
7 Remove suspect Fast Stop switch from loosened Control Panel.
8. Reassemble in reverse order.

Filament Driver PCB

The Filament Driver PCB mounts on top of the IGBT Snubber PCB next to the Generator Driver PCB as shown in the following illustration.



Filament Driver PCB Location

Follow these steps to replace the Filament Driver PCB:

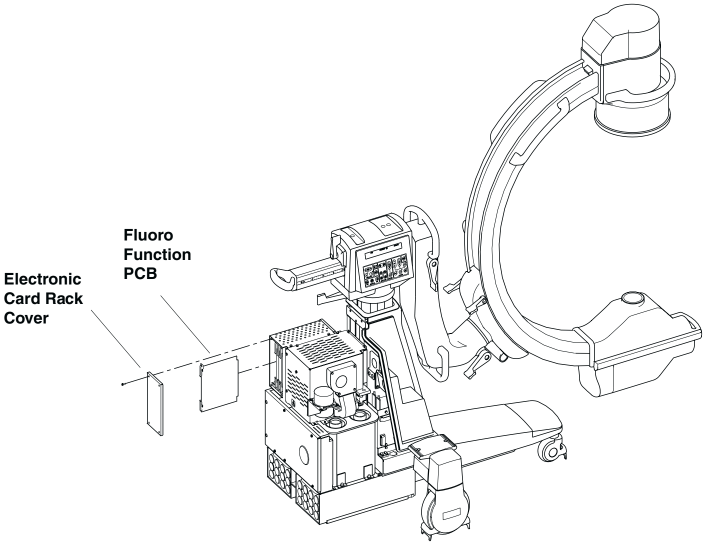
WARNING: ***Dangerous voltages are present when covers are removed from the C-Arm.***

1. Turn Workstation off and remove its AC power plug from the AC outlet.
2. Remove the Rear Cover and disconnect the steering linkage.

3. Remove the seven screws that secure the Generator Driver Cover and remove the cover.
4. Disconnect the cabling from the Filament Driver PCB.
5. Remove two screws from the Filament Driver heat sink.
6. Remove the Filament Driver PCB.

Fluoro Functions PCB

The Fluoro Functions PCB is the left-most PCB in the card rack assembly, which is located in the upper left-hand corner of the C-Arm chassis. Please refer to the following illustration for additional details.



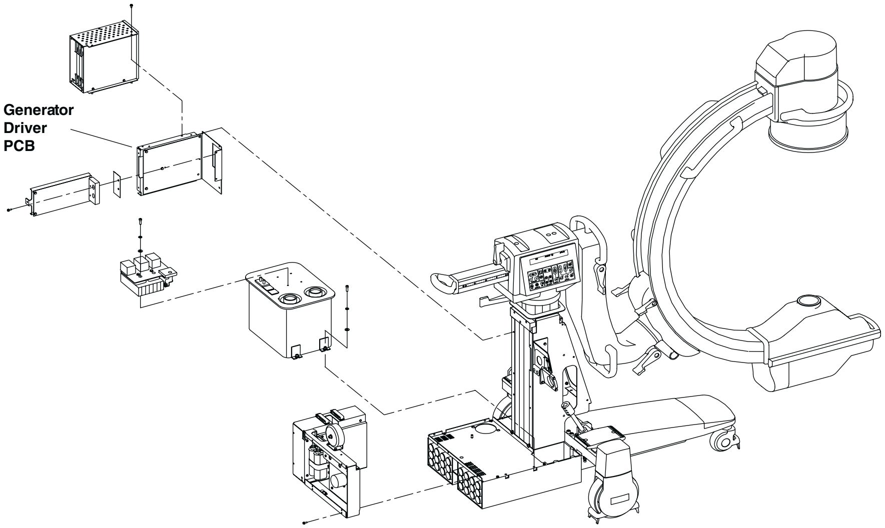
Fluoro Functions PCB

Follow these steps to replace the Fluoro Functions PCB:

1. Place the Workstation power switch in the OFF position and disconnect the Workstation's AC power cord from the AC outlet.
2. Remove the Rear Cover and disconnect the steering linkage.
3. Remove four screws that secure metal cover to the Electronic Card Rack.
4. Remove the Fluoro Functions PCB from the slot located to the far left in the Electronic Card Rack.

Generator Driver PCB

The Generator Driver PCB mounts in the C-Arm as shown next.



Generator Driver PCB Location

Follow the steps below to replace the Generator Driver PCB

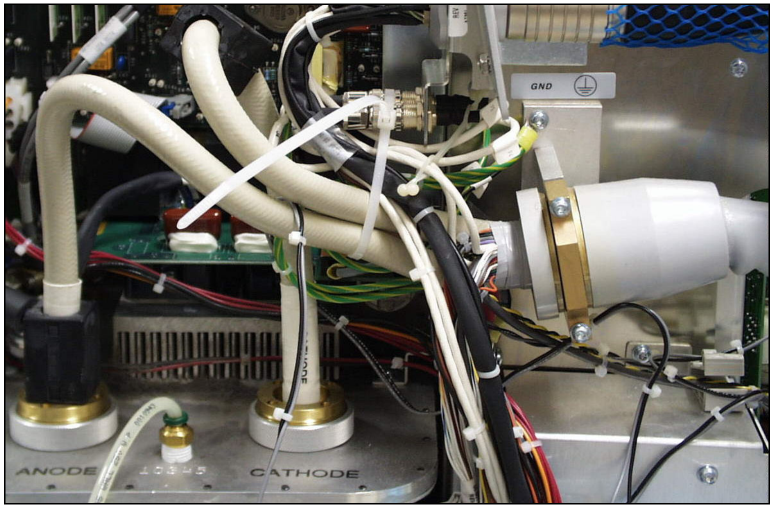
WARNING: ***Dangerous voltages are present when covers are removed from the C-Arm.***

1. Place the Workstation power switch in the OFF position and disconnect Workstation's AC power plug from AC outlet.
2. Remove the Rear Cover and disconnect the steering linkage.
3. Remove seven screws that secure the Generator Driver Cover and remove the cover.
4. Disconnect the cabling from the Filament Driver PCB.
5. Remove two screws from the Filament Driver heat sink.
6. Remove the Filament Driver PCB.
7. Remove five screws that secure the Generator Driver PCB.
8. Remove the Generator Driver PCB.

High Voltage and Control Cable Assembly

WARNING! The High Voltage and Control Cable Assembly carries highly lethal DC voltage even when the system is powered down and disconnected from the power line. Lethal static charges can remain on the cable long after the system has been turned off. Do not attempt to service or replace this cable until you are sure that the C-Arm is completely off, and you have taken steps to neutralize all electrostatic charges.

The High Voltage and Control Cable is the thickest cable assembly in the C-Arm. It runs through a large strain relief and grommet on the front of the C-Arm chassis to the C itself, where it services the X-ray tube, Collimator, Image Intensifier, and CCD Camera.



High Voltage and Control Cable Assembly

The High Voltage and Control Cable (GE OEC Part Number 901141) is a complex wiring assembly that contains many conductors, including the thick, highly insulated positive and negative cables that carry high voltage from the High Voltage tank to the X-ray tube. Only the entire cable is field replaceable. It is not possible to replace only a wire or two in the cable Assembly. You can, however, repair or replace broken wires or connectors at either end of the cable.

The following table shows the principal connections the High Voltage and Control Cable Assembly makes between the C-Arm chassis and components in the C. Refer to the C-Arm Interconnect Diagram (878980) for more information such as voltage levels and signal names.

High Voltage and Control Cable Signals

Runs From Connector	On Assembly	To Connector	On Assembly	Purpose
A1P8	Backplane	P8	CCD Camera	Camera Communications (Manchester serial)
A11J7	Power/Signal Interface PCB	P8	CCD Camera	Power to Camera
A4J5	Power/Motor Relay PCB	J15	X-ray Tube	Stator Run Voltages
J3	Camera	P1	Interconnect Cable Connector J1	Video to Workstation
J4	Camera	P1	Interconnect Cable Connector	Pilot Tone sync signal to Workstation
ANODE	HV Tank	ANODE	X-ray Tube	High Voltage positive with respect to Ground.
CATHODE	HV Tank	CATHODE	X-ray Tube	High Voltage Negative with respect to Ground.
A1J10	Backplane	J15	X-ray Tube	Housing Temperature analog signal from X-ray Tube

Runs From Connector	On Assembly	To Connector	On Assembly	Purpose
A4J11	Power/Motor Relay PCB	J18	Fan B3	12 VDC power to fan in C-Arm.
A1P8	Backplane	A14J7	Image Intensifier	Field size selection signal to II.
A1P8	Backplane	P8	CCD Camera	TEC power; camera position and movement signals

Use the above table to thoroughly troubleshoot the High Voltage and Control Cable assembly before replacing it. In most cases it will be much easier to repair a broken wire or connector than to replace the entire cable assembly. However, if you find irreparable damage to the cable, follow these steps to replace it:

1. Turn off the Workstation and remove its power plug from the AC outlet.
2. Remove the Rear Cover from the C-Arm.
3. Carefully check the High Voltage tank connectors for residual static charge. Drain all charges through appropriate current-limiting resistance before proceeding.
4. Peel back the rubber cable cover where the cable assembly enters the C and loosen the three setscrews that hold it in place.
5. Carefully disconnect and pull all control cables, high voltage cables, coaxial cables, power wires, and ground wires associated with the cable out of the C. You will need to disconnect wires at both the X-ray tube and II/Camera ends of the C. Tag all wires as you disconnect them.
6. Carefully disconnect and pull all control cables, high voltage cables, coaxial cables, and ground wires associated with the cable out of the Generator chassis. Again, tag all wires.
7. Finish removing the suspect High Voltage and Control Cable from the C-Arm. Keep the tagged cable handy for reference as you install the replacement cable
8. Use a fish tape to pull wires from the replacement cable into both ends of the C. Properly route and connect all wires. Make sure both high voltage cables are properly secured to the X-ray tube.

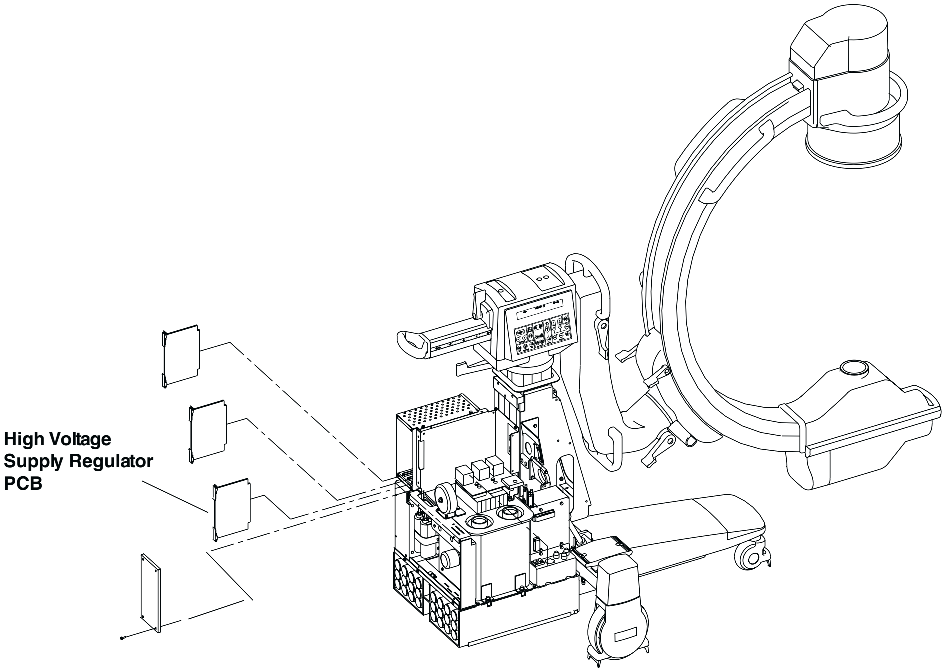
9. Insert the replacement cable's strain relief into the Generator chassis and tighten the setscrews.
10. Install all connectors on the Generator end of the cable and inspect your work. Be especially careful that the high voltage cables connect properly to the High Voltage Tank.
11. Carefully adjust all cable grommets and suspension devices.
12. Power up system and check for proper operation.

High Voltage Supply Regulator PCB

The High Voltage Supply Regulator PCB is located in the Electronic Card Rack, as shown in the following illustration.

Follow these steps to replace the High Voltage Supply Regulator PCB:

1. Place the Workstation power switch in the OFF position and disconnect the Workstation's AC power cord from the AC outlet.
2. Remove the Rear Cover and disconnect the steering linkage.
3. Remove four screws that secure metal cover to the Electronic Card Rack.
4. Remove the High Voltage Supply Regulator PCB from the slot located to the far left in the Electronic Card Rack.



High Voltage Supply Regulator PCB Location

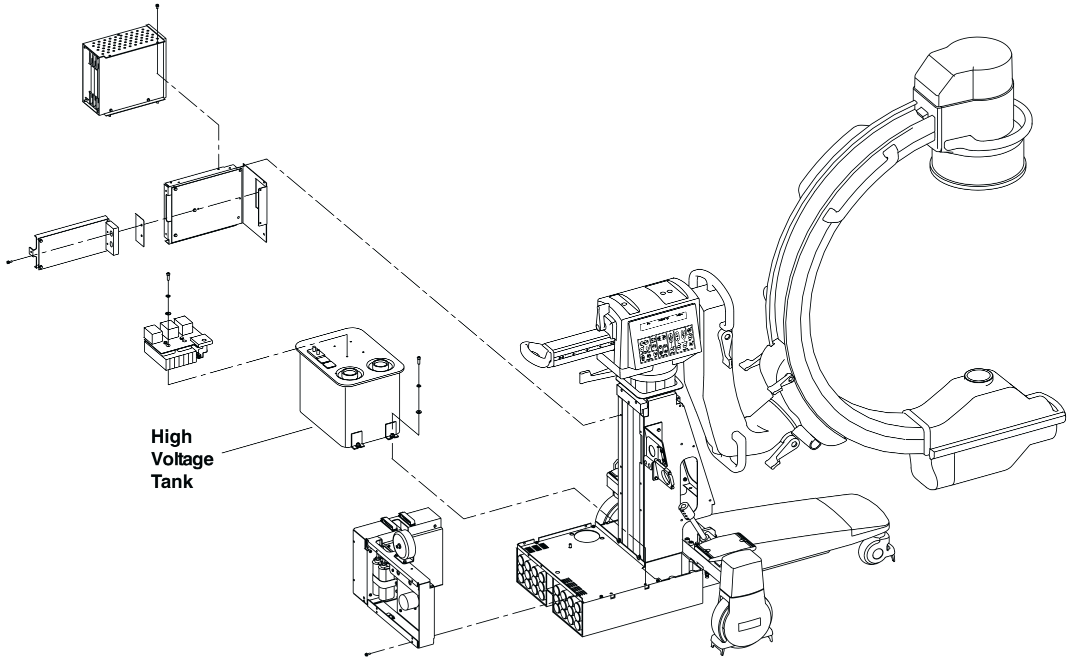
High Voltage Tank

The High Voltage Tank mounts above the batteries and is surrounded by electronic components as shown in the following illustration.

Use the following procedure to replace the High Voltage Tank:

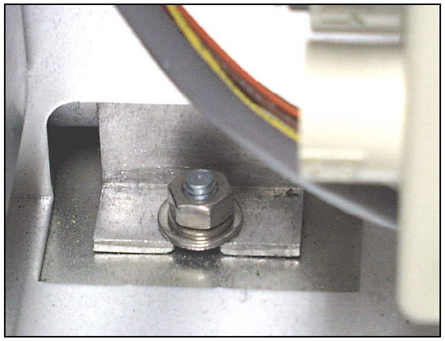
***WARNING**: Dangerous voltages are present at many points on the C-Arm.*

1. Turn off Workstation and disconnect its plug from the AC outlet.
2. Remove all C-Arm covers.
3. Disconnect steering linkage.
4. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect battery cables from P1A and P3B on Capacitor/Power module. (Refer to Capacitor/Power module replacement procedure in this chapter for details.)



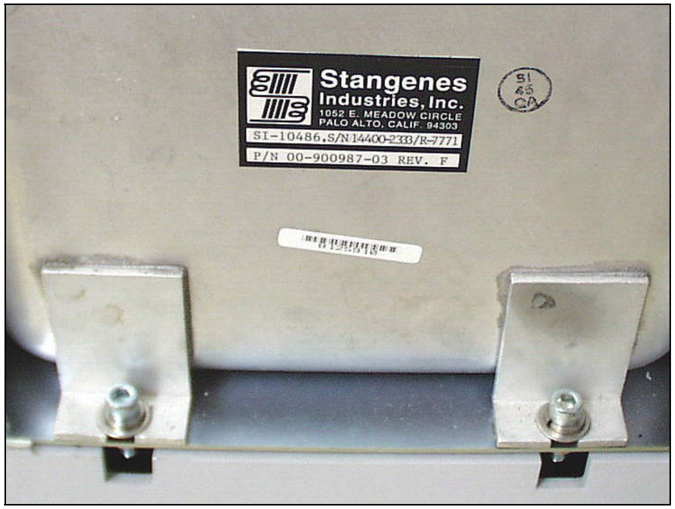
High Voltage Tank

5. Locate two battery cables just above P1A and P3B. These two cables have blue connectors that connect to each other. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect the cables from each other.
7. USING GREAT CARE TO AVOID ELECTRIC SHOCK, connect a current-limiting resistor (300k or so) across Capacitor/Power module busbars to discharge high energy capacitors inside Capacitor/Power module. (Refer to Capacitor/Power module replacement procedure in this chapter for more details.)
8. Remove Generator Driver cover and disconnect its DC fan. Tag fan connectors so you can find them later.
9. Remove and tag wires from connectors E1 and E2 on High Voltage tank.
10. Disconnect J1 from P1 on tank, and disconnect J2 from P2 on tank.
11. Follow procedure provided elsewhere in this chapter to remove Filament Driver PCB.
12. Follow procedure provided elsewhere in this chapter to remove IGBT Snubber PCB.
13. USING GREAT CARE TO AVOID ELECTRIC SHOCK, use spanner wrench to disconnect Anode cable from High Voltage tank and immediately discharge cable to ground through an appropriate current-limiting resistance.
14. USING GREAT CARE TO AVOID ELECTRIC SHOCK, use spanner wrench to disconnect Cathode cable from High Voltage tank and immediately discharge cable to ground through an appropriate current-limiting resistance.
15. Remove hex nut and washers that secure left side of tank to chassis. This fastener is accessible near PS3 on the left hand side of the chassis.



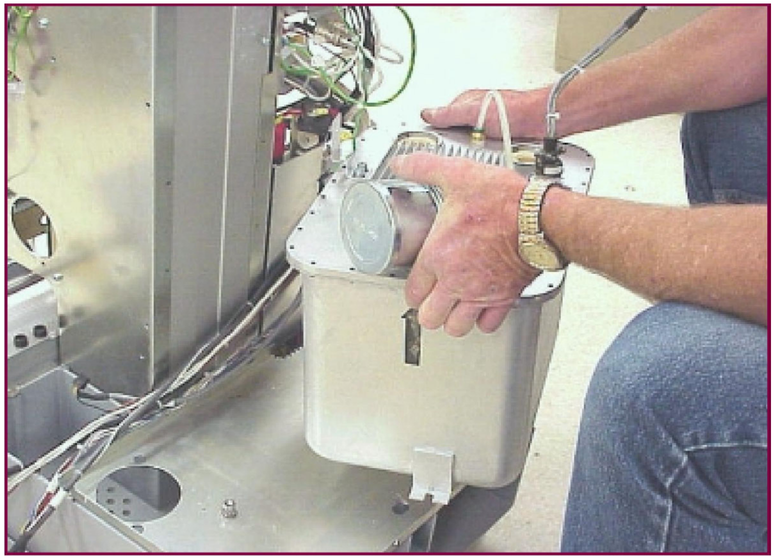
High Voltage Tank Fastener - Left Side

16. Remove two hex socket screws and associated washers that secure right-hand side of High Voltage tank to C-Arm chassis.


Stangenes
Industries, Inc.
1052 E. MEADOW CIRCLE
PALO ALTO, CALIF. 94303
SI-10486, S/N 14400-2333/R-7771
P/N 00-900987-03 REV. F

High Voltage Tank Fasteners - Right Side

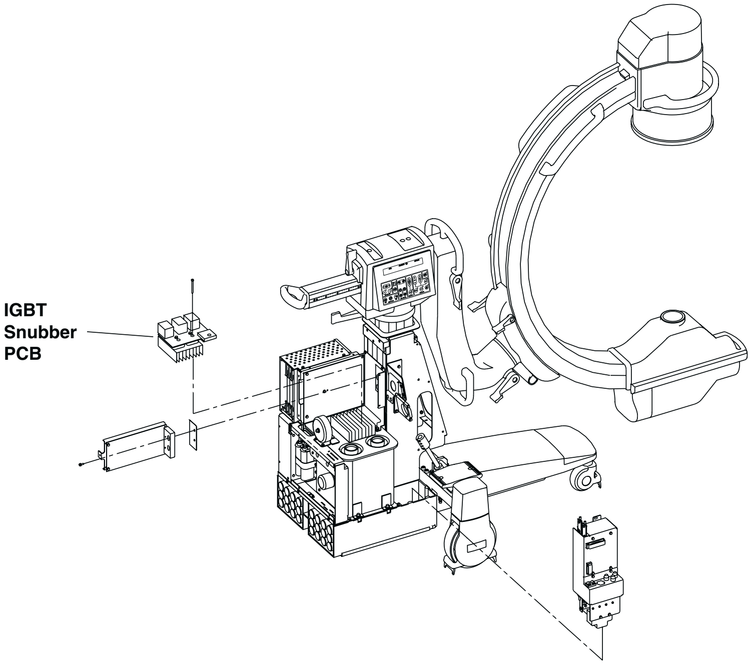
17 Taking care not to disconnect or damage transformer oil expansion tank or hose, move High Voltage Tank to the right and lift it carefully from the C-Arm chassis.



High Voltage Tank Removal

IGBT Snubber PCB

The IGBT Snubber PCB is located on top of the High VoltageTank and underneath the Filament Driver PCB as shown in the following illustration. Its heat sink attaches to the High Voltage Tank.



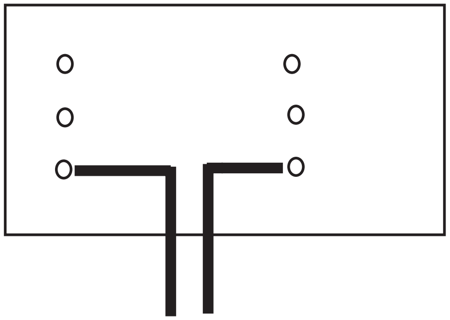
IGBT Snubber Location

Use the following procedure to replace the IGBT Snubber:

WARNING: ***Dangerous voltages are present when covers are removed from the C-Arm.***

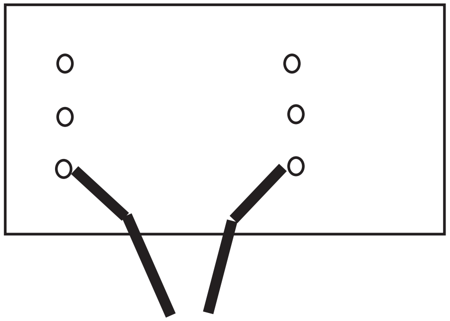
1. Turn the Workstation off and remove its power plug from the AC outlet.
2. Remove the C-Arm's Rear Cover and disconnect the steering linkage.
3. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect battery cables from P1A and P3B on Capacitor/Power module. (Refer to Capacitor/Power module replacement procedure in this chapter for more details.)
4. Locate two battery cables just above P1A and P3B. These two cables have blue connectors that connect to each other. USING GREAT CARE TO AVOID ELECTRIC SHOCK, disconnect battery cables from each other. (Refer to Capacitor/Power module replacement procedure in this chapter for more details.)
5. USING GREAT CARE TO AVOID ELECTRIC SHOCK, connect a current-limiting resistor (300k or so) across Capacitor/Power module busbars to discharge high energy capacitors inside Capacitor/Power module. (Refer to Capacitor/Power module replacement procedure in the chapter for more details.)
3. Turn OFF CB1 on the bottom of the Capacitor/Power Module.
4. Remove the seven screws that secure the Generator Driver Cover and remove the cover.
5. Remove the Filament Driver PCB to gain access to the IGBT Snubber PCB.
6. Remove the screws that secure the wire terminals to the IGBT PCB.
7. Remove two recessed hex bolts from the IGBT PCB
8. Remove two screws from the edge of the IGBT PCB.
9. Remove the IGBT PCB and integrated heat sink.
10. If you are replacing the H.V. Tank, remove the other half of the IGBT heat sink.

Note: When connecting the replacement snubber assembly to the tuned circuit, ensure that the lead wires exiting the snubber face each other LIKE THIS:



To Tuned Circuit

AND NOT LIKE THIS:



To Tuned Circuit

Image Intensifier and Power Supply

The Image Intensifier and its DC power supply mount on the C weldment opposite the X-ray tube as shown in the following illustration.

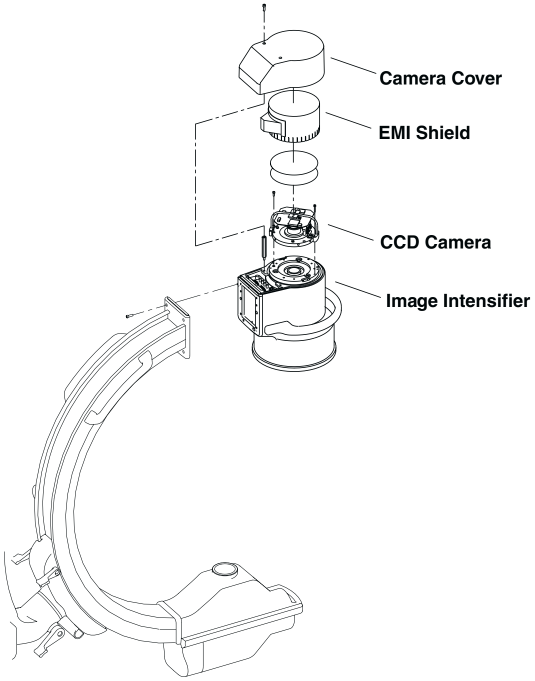

Camera Cover
EMI Shield
CCD Camera
Image Intensifier

Image Intensifier Location

Follow these steps to replace the Image Intensifier assembly.

1. Turn the Workstation off and remove its power cord from the AC outlet.

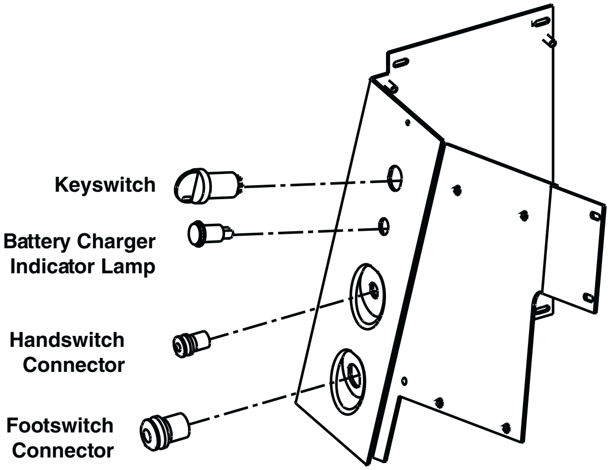
2. Position the C in a horizontal position with the Image Intensifier furthest from the C-Arm chassis.
3. Lock the C-Arm brake.

WARNING: Failure to install the C-Arm Safety Bolt may allow the gas spring to rotate the L-Arm very quickly and very forcefully when you remove the Image Intensifier. This could result in serious injury or equipment damage.

4. Remove the L-Arm end cap and install the C-Arm safety bolt as described in the L-Arm replacement procedure provided elsewhere in this chapter
5. Remove the CCD Camera as described elsewhere in this chapter.
6. Remove four socket hex bolts that secure the Image Intensifier assembly to the C-arm weldment.
7. Lift the Image Intensifier assembly up and disconnect all wiring from it.
8. Remove the Image Intensifier.
9. Reassemble in reverse order, installing replacement Image Intensifier. Check Beam Alignment.

Keyswitch

The Keyswitch is located on the C-Arm's Power Panel as shown below. It is readily accessible for testing or replacement.


Keyswitch
Battery Charger Indicator Lamp
Handswitch Connector
Footswitch Connector

Keyswitch

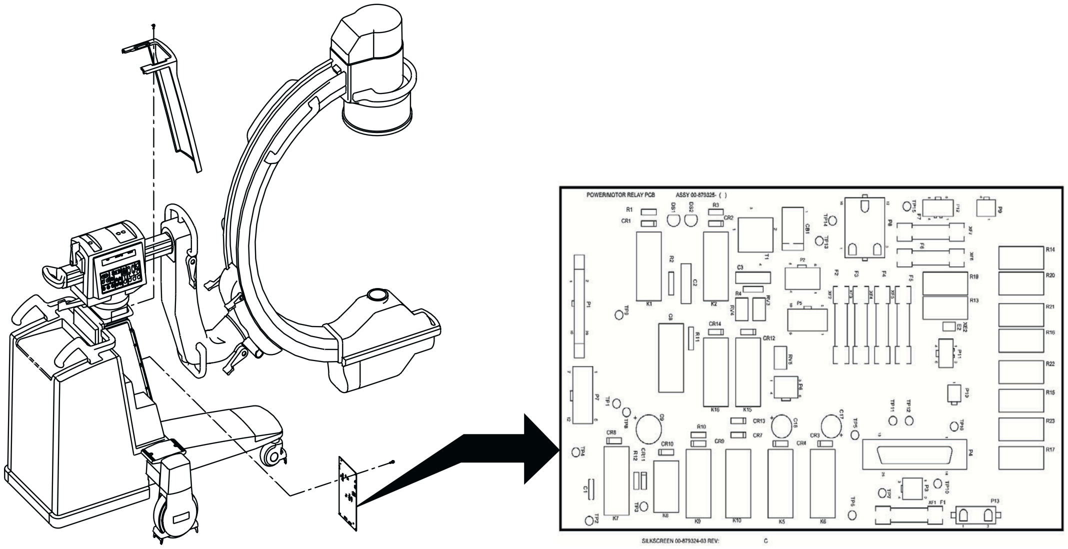
Follow these steps to replace the Keyswitch:

1. Remove the Front Cover.
2. Remove the Right Side Cover.
3. Remove the Rear Cover and disconnect the steering linkage.
4. Remove the Left Side Cover.
5. Remove the two Phillips screws that secure the Power Panel Door.
6. Open the Power panel Door.

7. Access the Power Panel Interior.
8. Trace the Keyswitch cable from the Keyswitch to the connector and disconnect the cable plug.
9. Remove the retaining nut from the Keyswitch.
10. Remove the Keyswitch from the front of the Power Panel.
11. Reassemble in reverse order mounting the Keyswitch so that the key's teeth face down when the key is in the Standby position.

Power Motor Relay PCB

The Power/Motor Relay PCB mounts at the front of the C-Arm as shown in the following illustration.


POWER/MOTOR RELAY PCB
ASSY 00-879325- ( )
R1
CR1
DS1
DS2
R3
CR2
T1
CB1
TP14
TP13
P8
TP15
F7
P12
P9
XF7
F6
XF6
R14
R20
R19
R13
R21
R16
R22
R15
R23
R17
P1
K1
R2
C2
K2
C3
R4
RV4
RV3
P2
P5
F2
F3
F4
F5
XF2
XF3
XF4
XF5
XE2
E2
P11
TP9
C8
R11
CR14
CR12
K16
K15
RV5
P6
P10
P7
TP1
TP8
C9
CR8
R10
CR13
CR7
C16
C17
CR3
CR4
CR9
CR10
CR11
R12
TP5
TP11
TP12
TP16
P4
TP4
C1
K7
K8
K9
K10
K5
K6
TP3
TP2
TP6
TP7
P3
TP10
XF1
F1
P13
SILKSCREEN 00-879324-03 REV:
C

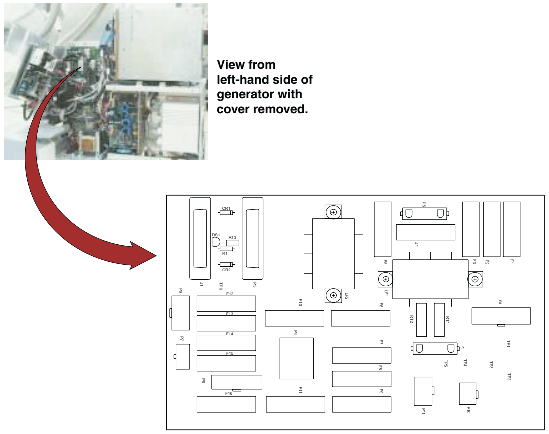
Power/Motor Relay PCB

Follow these steps to replace the Power/Motor Relay PCB:

1. Turn the Workstation off and disconnect its power plug from the AC outlet.
2. Remove the Front Cover by lifting the rubber gasket that surrounds the Vertical Column and removing two screws from each side.
3. Disconnect all wiring from the Power/Motor Relay PCB.
4. Remove four screws that secure the Power/Motor Relay PCB to the chassis.
5. Install replacement Power/Motor Relay PCB.
6. Reassemble C-Arm and check it for proper operation.

Power Signal Interface PCB

The Power/Signal Interface PCB is located under the Left Side Cover as shown next. For detailed access information, refer to the Overview section of this manual.



View from
left-hand side of
generator with
cover removed.

Power/Signal Interface PCB

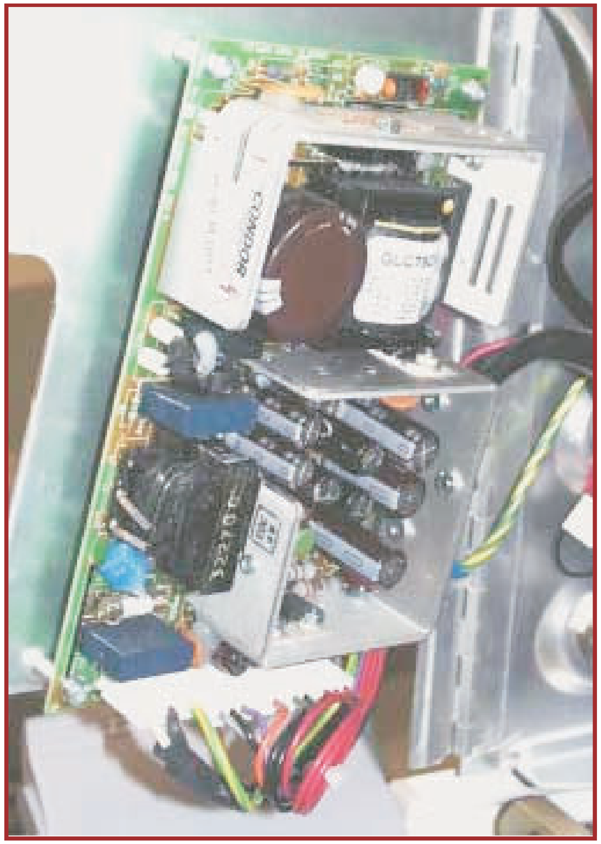
Replacement

Use the following procedure to replace the Power/Signal Interface PCB:

1. Turn off Workstation and disconnect its AC power plug from facility’s AC outlet.
2. Remove Left Side Cover from C-Arm.
3. Remove four screws and associated hardware that attach Power/Signal Interface PCB to C-Arm chassis. Retain hardware for reuse.
4. Disconnect and tag connectors from J1 and P2 through P11.
5. Inspect replacement Power/Signal Interface PCB for any obvious damage or missing components.
6. Attach connectors to J1 and P2 through P11 on replacement PCB.
7. Mount replacement Power/Signal Interface PCB to chassis and secure mounting hardware.
8. Connect Workstation’s AC power plug to AC outlet.
9. Check system for proper operation.
10. Install Workstation cover removed in step 2.

Power Supply PS1

Power Supply PS1 mounts under the Left Side Cover as shown in the next illustration. For detailed access information, refer to the Overview section of this manual.



Power Supply PS1

WARNING *Heat sinks on PS1 are at AC line potential.*

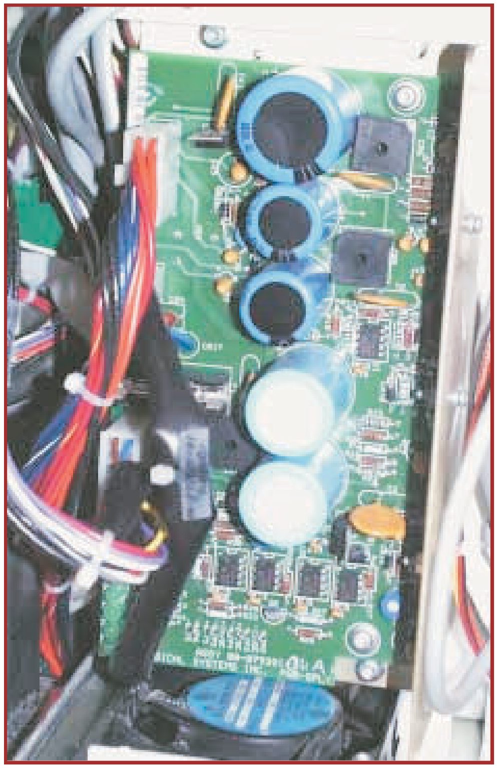
WARNING*:* *Dangerous AC line voltage is present on J1/P1.*

Follow these steps to replace PS1:

1. Turn off Workstation and disconnect Workstation’s AC power plug from AC outlet.
2. Remove Left Side Cover.
3. Remove and retain two torx screws that secure swing-out panel to left-hand side of C-Arm chassis.
4. Disconnect P1 from J1.
5. Disconnect P2 from J2.
6. Remove torx screw and washer that secure cable guide on side of PS1. Retain screw, washer, and cable guide for reuse.
7. Remove and retain four torx screws and lockwashers that secure PS1 to swing-out panel.
8. Lift PS1 out of C-Arm.
9. Inspect replacement power supply assembly for any obvious damage or missing components.
10. Mount replacement power supply assembly to chassis swing-out panel and secure mounting hardware.
11. Connect P1 to J1 and P2 to J2 on replacement power supply.
12. Mount cable guide removed in step 6 to replacement power supply. Secure screw and lockwasher.
13. Connect Workstation’s AC power plug to AC outlet.
14. Check system for proper operation.
15. Close swing-out panel and secure with torx screws and washers removed in step 3.
16. Reinstall Left Side Cover.

Power Supply PS2

PS2 mounts under the Left Side Cover as shown in the next illustration.



Multi-Output Power Supply PS2

Follow these steps to replace PS2:

WARNING: ***Dangerous AC line voltage is present on J2/P2 and J3/P3.***

1. Turn off Workstation and disconnect Workstation’s AC power plug from AC outlet.
2. Remove Left Side Cover.
3. Remove Component Tray Cover.
4. On PS2, disconnect J1 from P1, J2 from P2, and J3 from P3.
5. Remove and retain two torx screws that secure PS2 and its heat sink to C-Arm chassis.
6. Lift PS2 and heat sink out of C-Arm.
7. Inspect replacement power supply and heat sink for any obvious damage or missing components.
8. Mount replacement power supply assembly to C-Arm chassis and secure mounting hardware.
9. Connect P1 to J1, P2 to J2, and P3 to J3 on replacement power supply.
10. Connect Workstation’s AC power plug to AC outlet.
11. Check system for proper operation.
12. Reinstall Component Tray Cover.
13. Reinstall Left Side Cover.

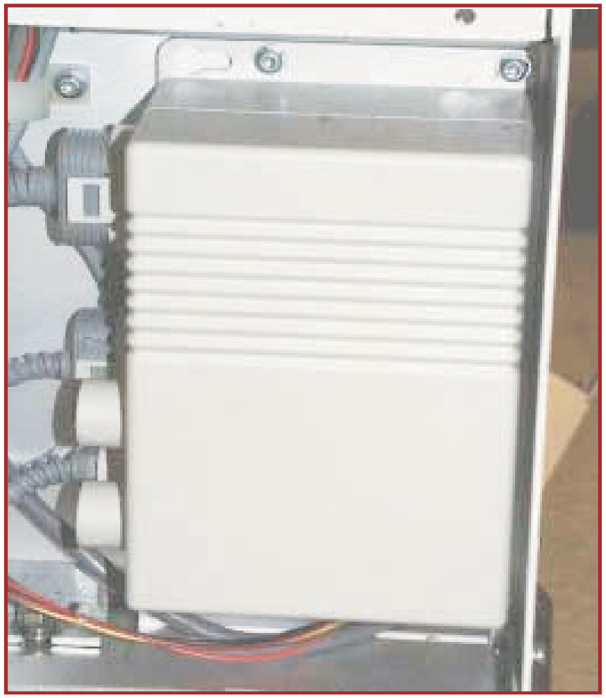
Power Supply PS3

PS3 mounts on the left-hand side of the C-Arm chassis under the Left Side Cover and Component Tray Cover. It has no external controls and only three connectors.

Follow these steps to replace PS3:

WARNING: ***Dangerous AC line voltage is present on PS3's POWER connector.***

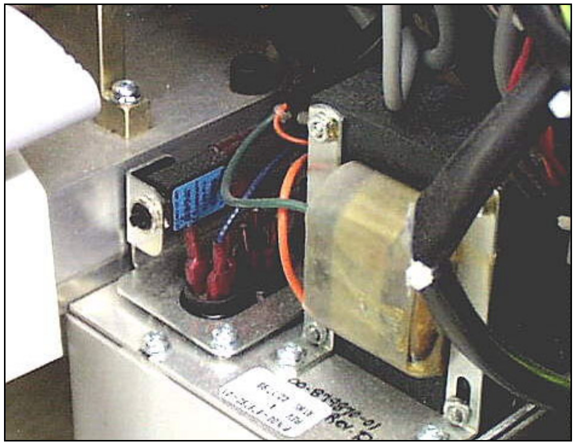
1. Turn off Workstation and disconnect its AC power plug from AC outlet.
2. Remove Left Side Cover.
3. Remove Component Tray Cover.
4. Remove and retain four torx screws and washers that secure PS3 to C-Arm chassis.
5. Disconnect POWER, CONTROL, and OUTPUT connectors from PS3.
6. Lift PS3 out of C-Arm.
7. Inspect replacement power supply for any obvious damage or missing components.
8. Connect POWER, CONTROL, and OUTPUT connectors to replacement power supply.
9. Mount replacement power supply assembly to C-Arm chassis and secure mounting hardware.
10. Connect Workstation's AC power plug to AC outlet.
11. Check system for proper operation.
12. Reinstall Component Tray Cover.
13. Reinstall Left Side Cover.



Power Supply PS3

Stator Capacitor/Transformer Assembly

The Stator Capacitor/Transformer Assembly mounts on the left-hand side of the C-Arm, where it serves as a mounting point for the Stator start and run capacitors, the Stator/precharge transformer (T3, located on top of the assembly), CB2, which protects T3, and T2, which mounts out of sight on the bottom side of the assembly and supplies AC power to multi-output power supply PS2.



Stator Capacitor/Transformer Assembly

Follow these steps to replace the Stator Capacitor/Transformer Assembly

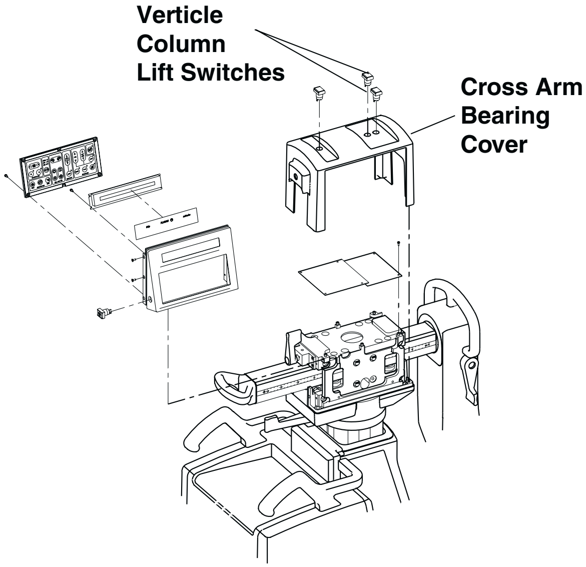
1. Turn off Workstation and disconnect its power plug from facility's AC outlet.
2. Remove two screws that secure the Stator Capacitor/Transformer Assembly to C-Arm chassis.
3. Disconnect all wires from Assembly and tag them.
4. Remove the Stator Cap/Transformer Assembly from C-Arm chassis.

Vertical Column Lift Switches

The two Verical Column Lift switches are each part of a replaceable cable assembly. Each cable assembly mounts in the Cross Arm Bearing cover as shown next.

The following procedure describes how to replace either Vertical Column movement switch assembly.

1. Turn off Workstation and remove its power plug from facility's AC outlet.
2. Remove Cross Arm Bearing Cover as described elsewhere in this chapter.
3. Loosen suspect switch by removing its locking ring and pushing the switch upward through Cross Arm Bearing cover.
4. Disconnect switch cable and tag connector.
5. Install replacement switch and connect its cable to connector you tagged in step 4.
6. Install Cross Arm Bearing cover.
7. Power up system and test replacement switch for proper operation.


Verticle
Column
Lift Switches
Cross Arm
Bearing
Cover

Vertical Column Lift Switches

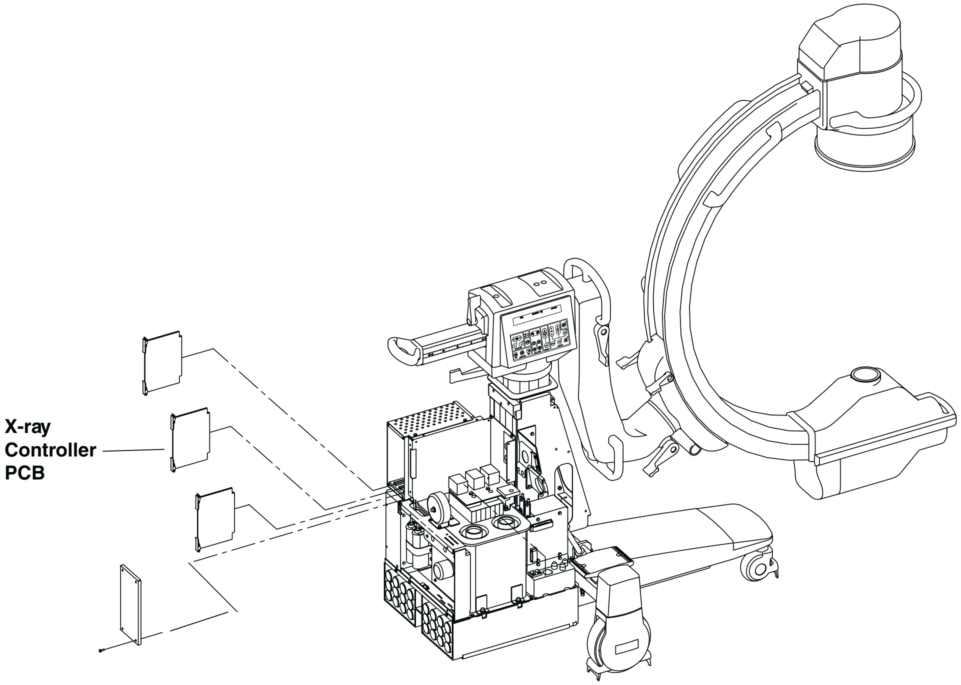
X-ray Controller PCB

The X-ray Controller PCB mounts in the Electronic Card Rack as shown next.

WARNING: ***Dangerous voltages are present when covers are removed from the C-Arm.***

Follow these steps to replace the X-ray Controller PCB:

1. Turn off Workstation and remove its power plug from facility's AC outlet.
2. Remove the Rear Cover and disconnect the steering linkage.
3. Remove the Electronic Card Rack Cover.
4. Remove suspect X-ray Controller PCB.
5. Install replacement X-ray Controller PCB.
6. Install Electronic Card Rack Cover.
7. Power up system and check for proper operation.
8. Install covers and reconnect steering linkage.


X-ray
Controller
PCB

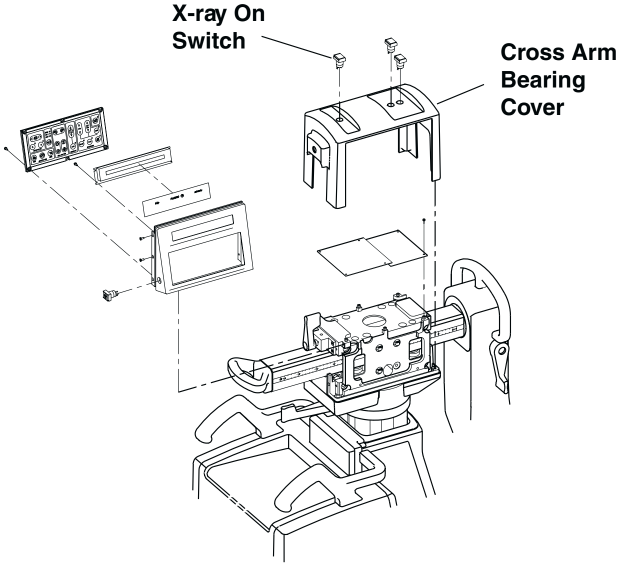
X-ray Controller PCB Location

X-ray On Pushbutton

The X-ray On pushbutton is part of a replaceable cable assembly that mounts in the Cross Arm Bearing cover as shown next.

The following procedure describes how to replace the X-ray On Pushbutton.assembly.

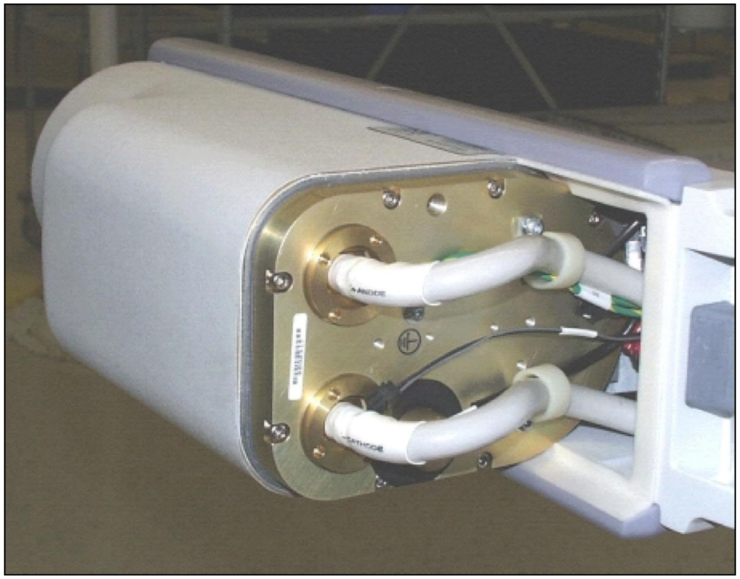
1. Turn off Workstation and remove its power plug from facility's AC outlet.
2. Remove Cross Arm Bearing Cover as described elsewhere in this chapter.
3. Loosen suspect switch by removing its locking ring and pushing the switch upward through Cross Arm Bearing cover.
4. Disconnect switch cable and tag connector.
5. Install replacement switch and connect its cable to connector you tagged in step 4.
6. Install Cross Arm Bearing cover.
7. Power up system and test replacement switch for proper operation.


X-ray On
Switch
Cross Arm
Bearing
Cover

X-ray On Pushbutton

X-ray Tube

The X-ray tube mounts on the C-Arm opposite the Image Intensifier. The following illustration shows a view of the tube and High Voltage cables.



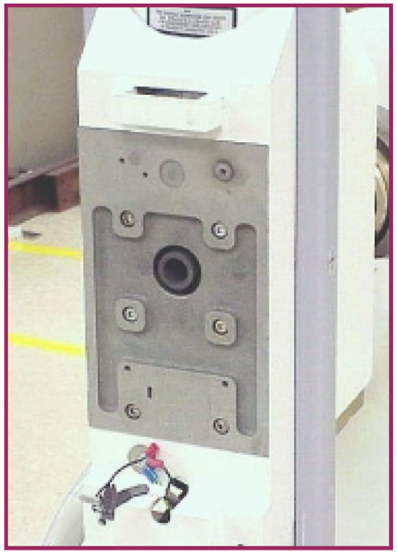
X-ray Tube Assembly

WARNING: Failure to install the C-Arm Safety Bolt may allow the gas spring to rotate the L-Arm very quickly and very forcefully when you remove the X-ray Tube. This could result in serious injury or equipment damage.

WARNING Lethal high voltage is present on the X-ray tube and high voltage cables, even when system is turned off. Be sure to turn system off and carefully discharge high voltage from cables before working near X-ray tube or cables.

Follow these steps to remove the X-ray tube:

1. Turn off Workstation and remove its power plug from facility's AC outlet.
2. If your system is not a Super C, install C-Arm Safety Bolt. Follow the procedure provided elsewhere in this chapter.
3. Remove the Collimator. Follow the procedure provided elsewhere in this chapter.
4. Position the C-Arm so that it is vertical with the X-ray tube on top. Then perform an orbital movement of the C so that X-ray tube's mounting bolts are accessible and X-ray tube is about waist high.



X-ray Tube Positioned for Removal

5. USING GREAT CARE TO AVOID ELECTRIC SHOCK, use spanner wrench to disconnect Anode cable from X-ray tube and immediately discharge cable to ground through an appropriate current-limiting resistance.
6. USING GREAT CARE TO AVOID ELECTRIC SHOCK, use spanner wrench to disconnect Cathode cable from X-ray tube and immediately discharge cable to ground through an appropriate current-limiting resistance.
7. USING GREAT CARE TO AVOID ELECTRIC SHOCK, discharge Anode and Cathode connectors on X-ray tube to ground through an appropriate current-limiting resistance.
8. Disconnect J15 from P15 on X-ray tube's wiring harness.
9. Disconnect ground wires E5 and E6 from X-ray tube.

CAUTION: *As soon as you remove fasteners in the following step, the X-ray tube will fall freely from the C-arm. The X-ray tube is heavy (about 40 pounds) and expensive. Get somebody to help you hold the X-ray tube steady in the following step and prevent it from falling to the floor.*

10. Get somebody to help you hold the X-ray tube steady, and then remove the 6 hex-keyed bolts that secure the X-ray Tube to C weldment.
11. Stow removed X-ray tube in padded container.
12. Get somebody to help you move the replacement X-ray tube into position on the C weldment.
13. Install the six bolts you removed in step 10.
14. Connect ground wires E5 and E6 to X-ray tube.
15. Connect J15 to P15 on X-ray tube's wiring harness.
16. Connect Anode and Cathode cables to replacement X-ray tube. Use spanner wrench to secure fasteners.
17. Install Collimator.
18. Power up system and check for proper X-ray tube operation.
19. Perform beam alignment.
20. Install covers and return system to service.

Mechanical Assemblies

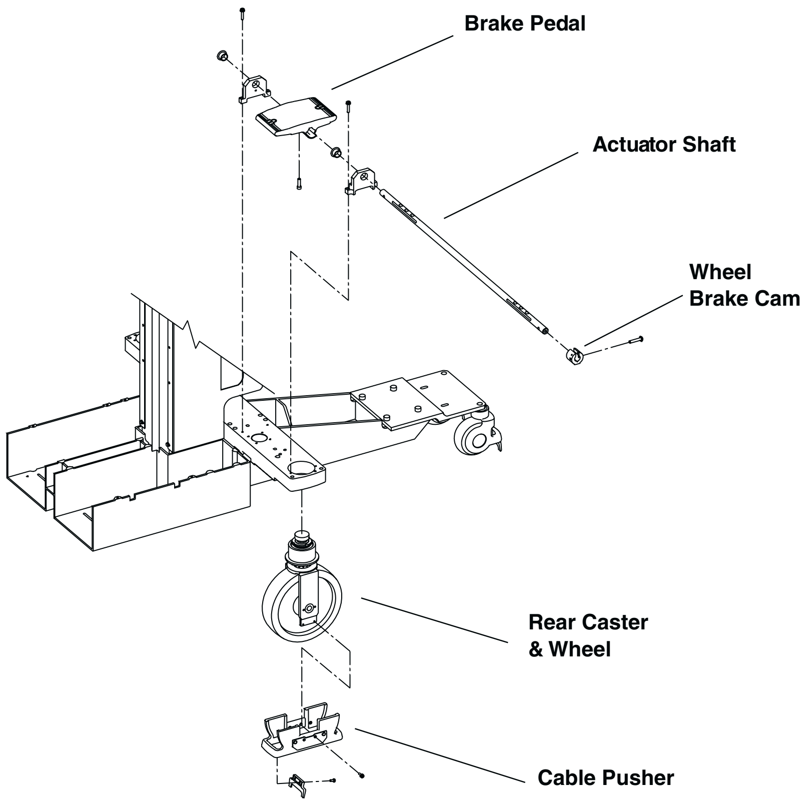
The following paragraphs describe field replacement of certain C-Arm mechanical assemblies.

Cable Pushers

The following illustration shows one rear caster Cable Pusher:

Follow these steps to remove a Cable Pusher or Wheel:

1. Remove two screws from the End Cap cover and remove the End Cap.
2. Remove the decals from each side of the Wheel assembly.
3. Remove the hole plug (right/top) from each side of the Wheel assembly and retain the plugs.
4. Remove the Allen Screw from each hole plug.
5. Remove four screws (two each side) from the Wheel Covers (located where the decals were).
6. Remove the Wheel Covers from each side of the Wheel.
7. Jack the Wheel Axle up approximately 2 - 2.5 inches.
8. Remove four Torx Screws (two each side).
9. Remove the Cable Pusher Assembly and then remove the Cable Pusher Assemblies Feet by removing 2 screws from each side.
10. To remove the wheel from the Rear Wheel Assembly, remove the 1/2-inch bolt.


Brake Pedal
Actuator Shaft
Wheel
Brake Cam
Rear Caster
& Wheel
Cable Pusher

Cable Pusher Assembly

C Removal

The "C" is the C-shaped weldment that supports the X-ray tube and Collimator on one end and the Image Intensifier and CCD camera on the other end. Removing the C is a simple task but some heavy lifting is involved. Follow these steps:

WARNING: *Failure to install the C-Arm Safety Bolt may allow the gas spring to rotate the L-Arm very quickly and very forcefully when you remove the C from the end of the L-Arm. This could result in serious injury or equipment damage.*

1. Turn off power to the Workstation and remove its power plug from the AC outlet.
2. Follow the procedure provided in this chapter under *Electrical and Electronic Assemblies* to remove the Image Intensifier from the C. THIS INCLUDES INSTALLING THE C-ARM SAFETY BOLT.

3 Remove the four hex-keyed bolts that secure the Image Intensifier mounting plate to the C.

4. Carefully separate the Image Intensifier mounting plate from the C.

CAUTION: *Step 5 requires some careful heavy lifting. Get somebody to help you.*

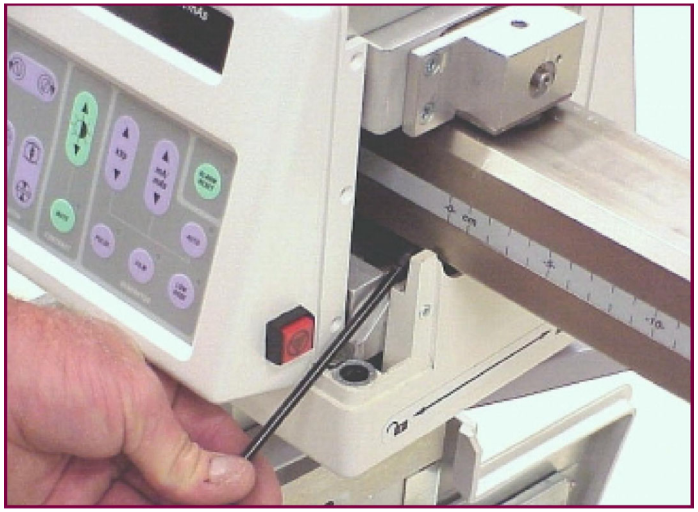
CAUTION: *Be careful not to damage the High Voltage and Control Cable assembly in the following step.*

5. Loosen the Orbital brake.
6. Rotate the Image Intensifier end of the C through the Flip Flop assembly.
7. Carefully lift the C out of the Flip Flop assembly and set it aside.

Cross-Arm

Note: The following procedure does not separate the Flip Flop assembly or L-arm assembly from the Cross Arm.

1. Turn off Workstation and disconnect its power plug from facility's AC outlet.
2. Remove the "C" from the Flip Flop assembly as described elsewhere in this chapter.
3. Remove the mechanical stop (hex bolt) from the Cross-Arm as shown next.

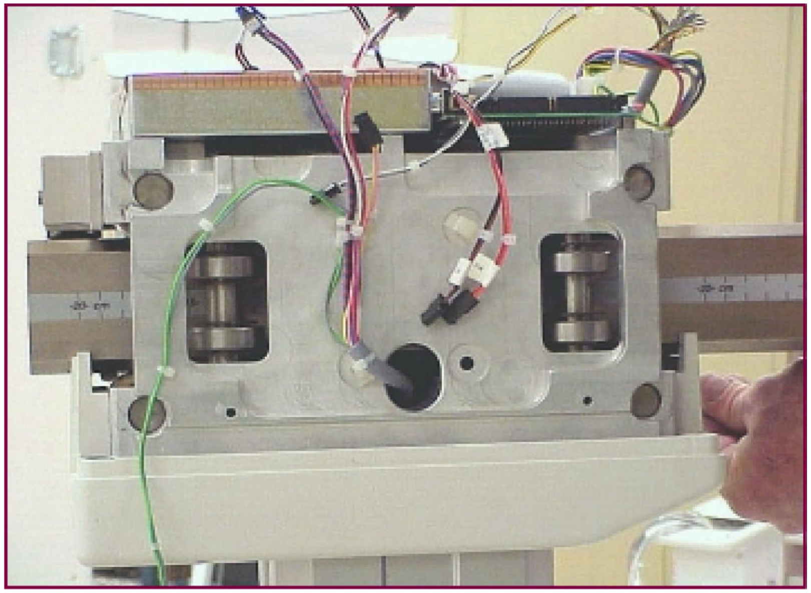


Cross Arm Mechanical Stop Removal

4. Use a pin-punch and hammer to punch out the rolled pin that secures the Cross-Arm Handle. The roll pin is located on the bottom side of the Cross-Arm.
5. Remove the Cross-Arm Handle.

***Note**: The C-arm will tip backwards onto the balance wheel when you remove the Cross Arm in the following step. This is normal.*

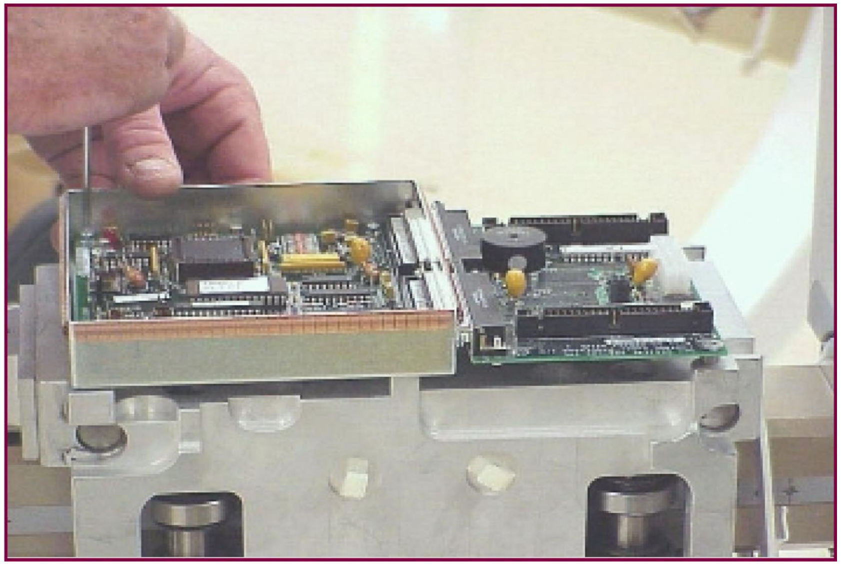
6. Grasp L-Arm handle and pull Cross-Arm out of the Cross-Arm Bearing Block assembly as shown below.



Cross Arm Removal

Cross-Arm Bearing Block

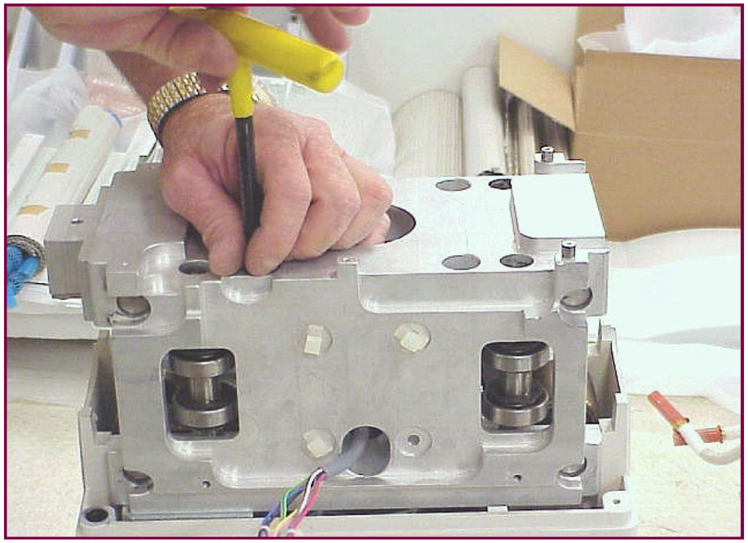
1. Turn off Workstation and disconnect its power plug from the AC outlet.
2. Remove C from Flip Flop assembly. Follow procedure provided in this chapter.
3. Remove Cross Arm Bearing cover. Follower procedure provided in this chapter.
4. Remove Cross Arm from Cross Arm Bearing Block by following procedure in this chapter.
5. Remove six screws that secure the Control Panel Processor and Control Panel I/O PCBs to bearing block and remove both PCBs as an assembly.



CPP and CPP I/O PCB Removal

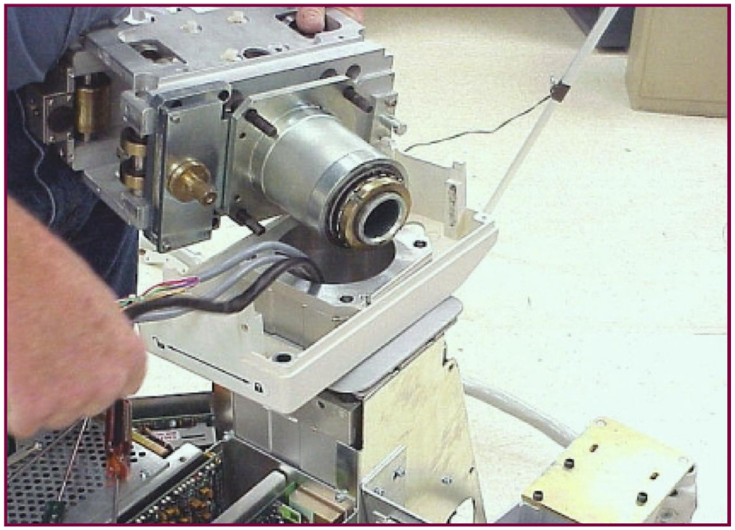
6. Remove screw that secures the Wig-Wag Brake Handle to Wig Wag brake and remove handle.

7. Remove four screws that secure bottom half of Control Panel Bearing Block cover to bearing block..
8. Lower the bottom half of the Control Panel Bearing Block Cover.
9. Cut all wiring tie wraps, noting wire locations and routing. Tagging the wires and connectors will be helpful in reassembly.
10. Remove four hex keyed bolts that secure Bearing Block assembly to the Lift Column.



Bearing Block Assembly Mounting Bolt Removal

7. Lift up the Bearing Block slowly and carefully remove the cables.
8. Remove the Bearing Block.

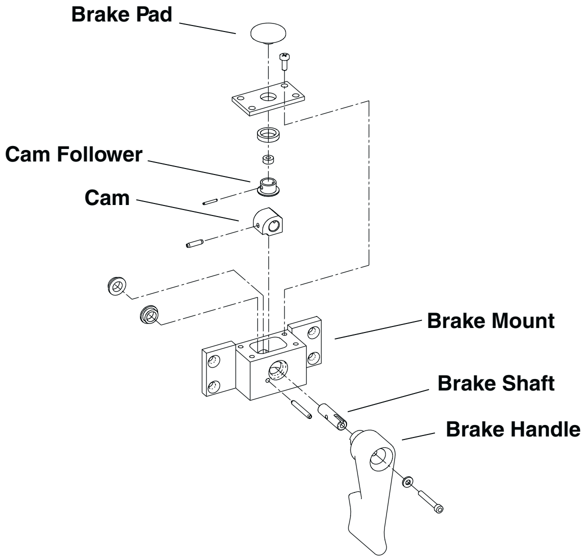


Lifting Bearing Block from Vertical Column

***Note**: To remove a bearing from the Bearing Block: (a) Loosen the corresponding set screw that secures the shaft. The set screw is recessed into the Bearing Block and secures the shaft in place. Each bearing assembly has 1 set screw. (b) Remove the retaining rings from both sides of each bearing and pull the shaft out. (c) Replace the bearing(s).*

Cross Arm Brake

The following illustration shows the Cross Arm brake assembly. Setting the Cross Arm brake engages a brake pad that restricts the movement of a bearing in the Cross Arm housing. This prevents the Cross Arm from moving.



Cross Arm Brake Assembly

Follow these steps to replace the Cross Arm brake pad:

1. Remove the hole plug in the Cross Arm Brake Handle.
2. Remove the torx screw that secures the Cross Arm Brake Handle to the Brake Shaft.
3. Remove Cross Arm Bearing cover as described elsewhere in this chapter.
5. Remove four Torx screws that secure the Cross Arm Brake Mount to the Cross Arm Bearing housing.

6. Remove the Cross-Arm Brake Pad.

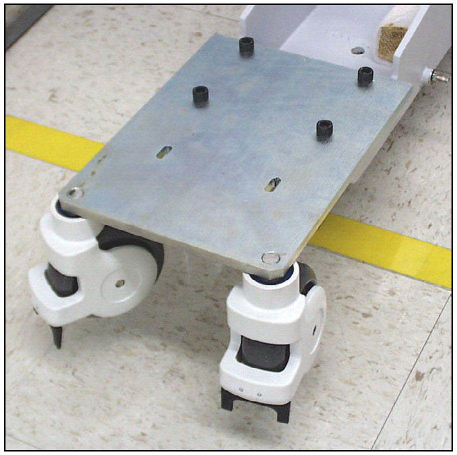
Flip Flop

For disassembly of the Flip Flop rotation assembly and brake, refer to the L-arm section of this chapter.

Front Casters

The following procedure explains how to replace the Front Casters.

The two Front Caster wheels mount on a plate that is located under the Front Leg cover. The following illustration shows the casters with the cover removed and the decals off the axle screws.



Front Caster Assembly

Each caster is press fit into the mounting plate. The following picture shows individual caster details.

Front Caster

To replace a caster wheel:

1. Jack the mounting plate edge nearest the damaged wheel. Get the wheel about half an inch off floor.
2. Carefully remove the adhesive cover that conceals the axle screw. Retain the cover for reuse.
3. Use a hex key to loosen the axle.
4. Remove the axle and the damaged wheel.
5. Install replacement wheel and secure the axle.
6. Reinstall adhesive axle cover over axle screw.

To replace a cable pusher.

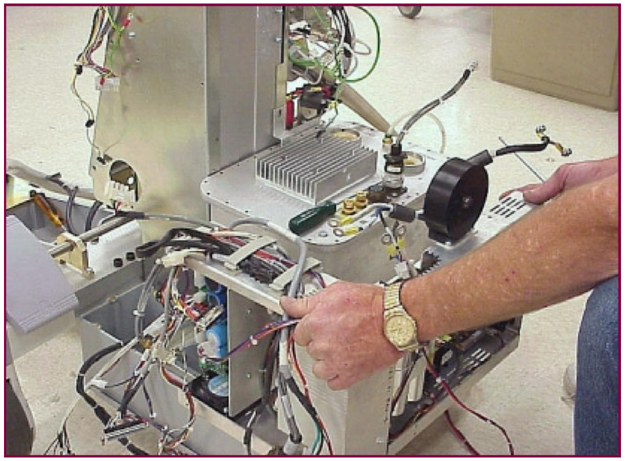
1. Jack mounting plate and remove the associated wheel as just described.
2. Remove torx screws that secure damaged cable pusher.
3. Install replacement cable pusher using screws removed in step 2.

To replace caster parts other than wheels or cable pushers, you must replace the entire Front Caster assembly. Remove the four hex keyed bolts shown in the above illustration and install a new Front Caster assembly. Refer to the Illustrated parts manual for the current part number.

Generator Tray

The following paragraphs describe how to replace the Generator Tray:

1. Remove five screws that secure the L-shaped Generator Tray to C-Arm chassis.
2. Lift Generator Tray from chassis.



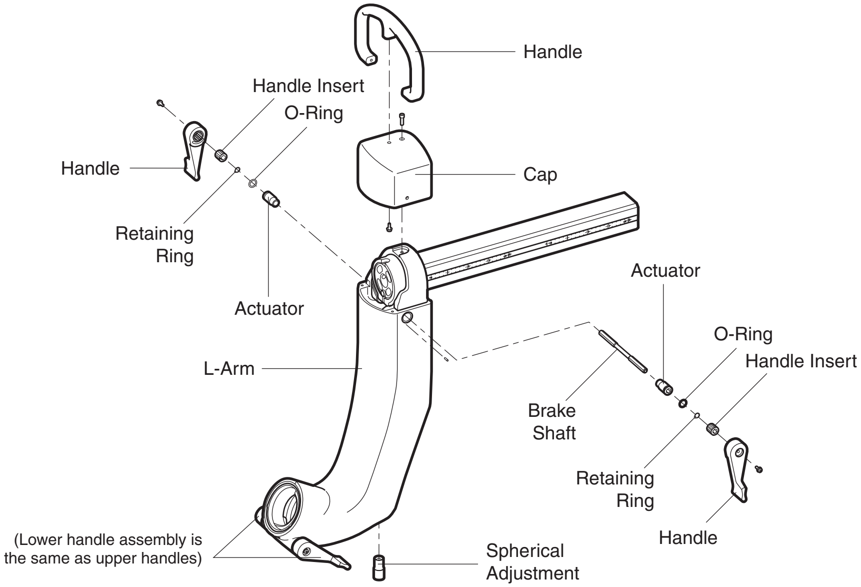
Generator Tray Removal

L-Arm and L-rotation Assembly

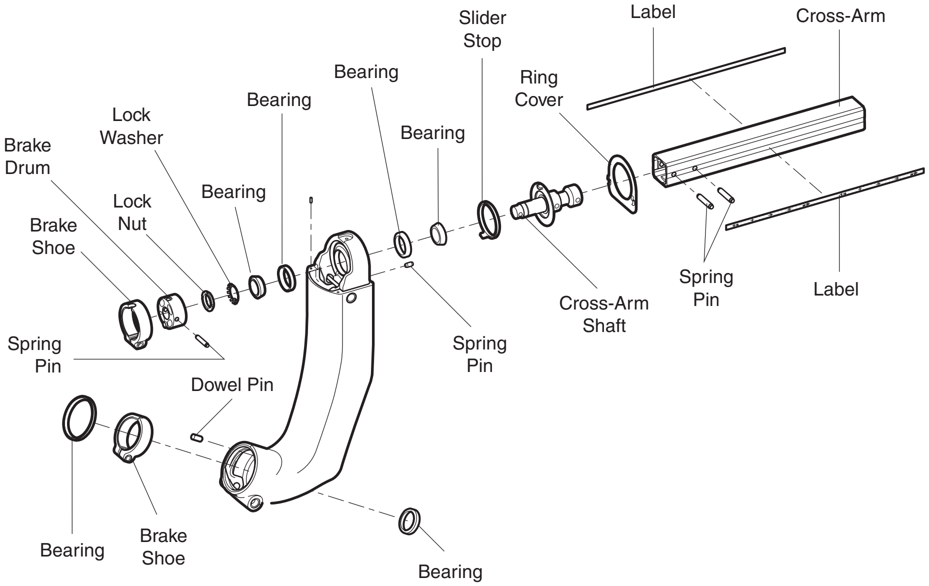
To separate the L-Arm from the Cross Arm, perform the following (see applicable pictures following):

WARNING*:* *Verify that the L-Arm Gas Spring locking bolt is inserted. Failure to disable the L-Arm may result in the gas spring spinning the L-Arm or Cross-Arm. This could result in serious personal injury.*

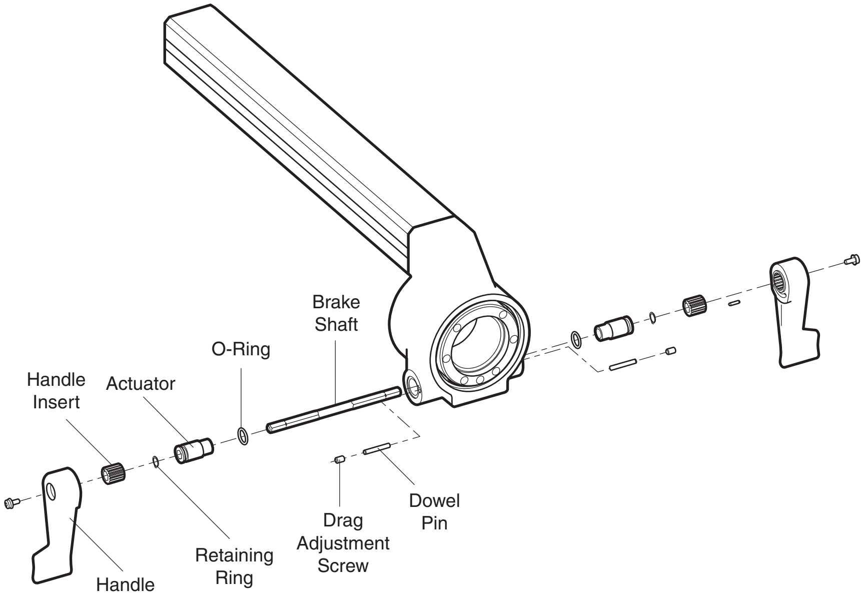
1. Pull back the Cross-Arm decals from the end of the Cross-Arm nearest the L-Arm.
2. Dislocate two roll pins from the Cross-Arm.
3. Separate the L-Arm from the Cross-Arm.
4. Reassemble in reverse order and replace the decals.


Handle
Handle Insert
O-Ring
Handle
Cap
Retaining
Ring
Actuator
Actuator
L-Arm
O-Ring
Handle Insert
Brake
Shaft
Retaining
Ring
Handle
(Lower handle assembly is
the same as upper handles)
Spherical
Adjustment

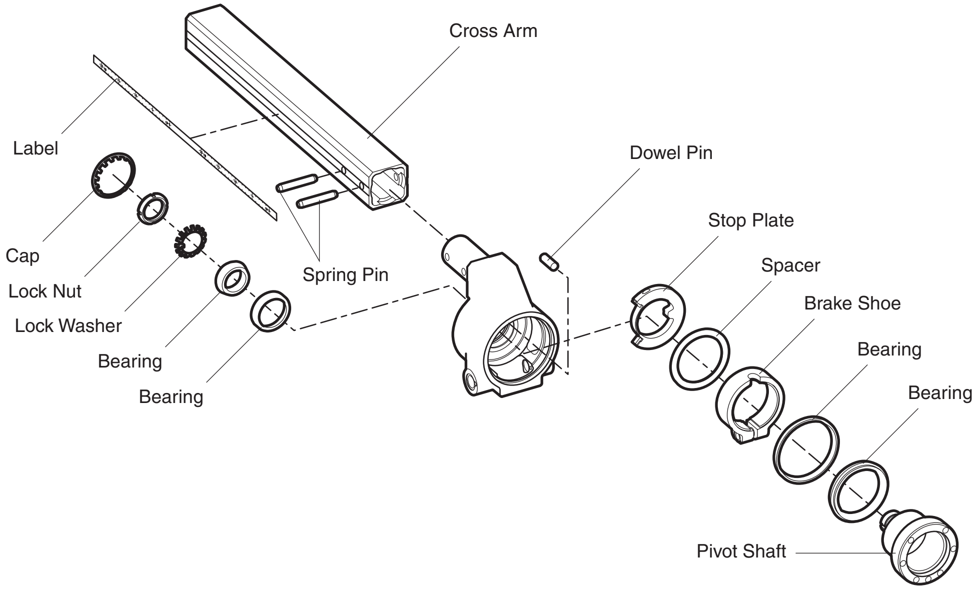
Standard C-arm (sheet 1)


Slider Stop
Label
Cross-Arm
Bearing
Ring Cover
Bearing
Lock Washer
Bearing
Brake Drum
Bearing
Lock Nut
Brake Shoe
Spring Pin
Cross-Arm Shaft
Spring Pin
Label
Spring Pin
Spring Pin
Dowel Pin
Bearing
Brake Shoe
Bearing

Standard C-arm (sheet 2)


Brake
Shaft
O-Ring
Handle
Insert
Actuator
Dowel
Pin
Drag
Adjustment
Screw
Retaining
Ring
Handle

Super-C (sheet 1)

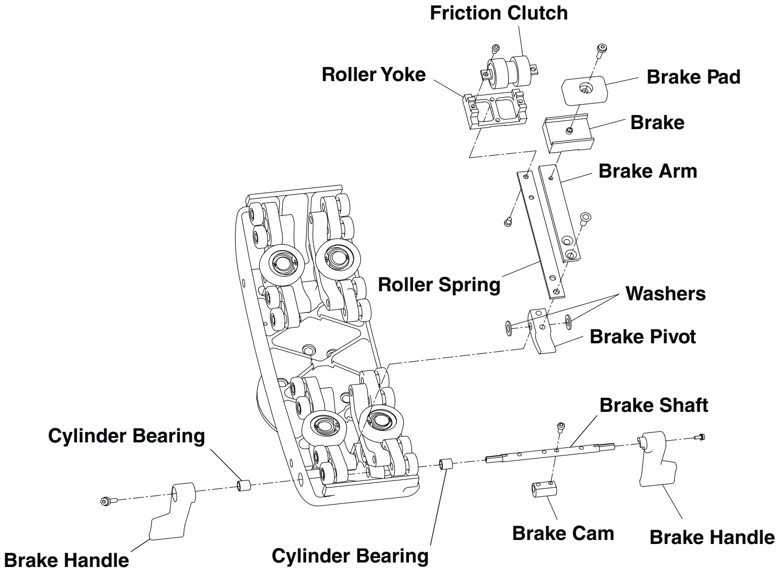

Cross Arm
Label
Dowel Pin
Cap
Lock Nut
Lock Washer
Bearing
Bearing
Spring Pin
Stop Plate
Spacer
Brake Shoe
Bearing
Bearing
Pivot Shaft

Super-C (sheet 2)

Orbital Brake

This section describes the replaceable components associated with the Orbital Brake.

The following illustration is an exploded view of the C-Arm's Orbital Brake assembly.


Friction Clutch
Roller Yoke
Brake Pad
Brake
Brake Arm
Roller Spring
Washers
Brake Pivot
Brake Shaft
Cylinder Bearing
Brake Cam
Brake Handle
Brake Handle
Cylinder Bearing

Orbital Brake Assembly

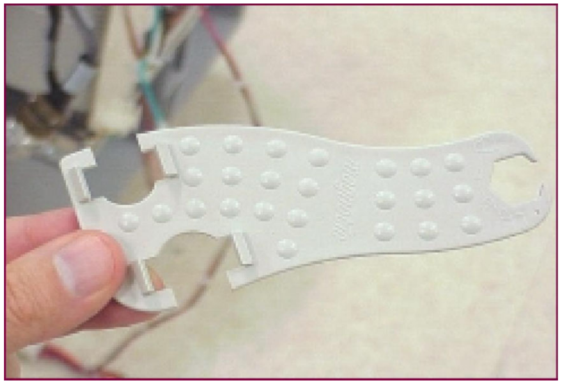
If the Orbital brake does not prevent C-Arm orbital rotation, you must replace the Brake Pad. There are no brake adjustments. Follow these steps to replace the brake pad:

1. Remove the C-Arm.
2. Remove the screw that secures the Brake Pad.

3. Replace the Brake Pad.

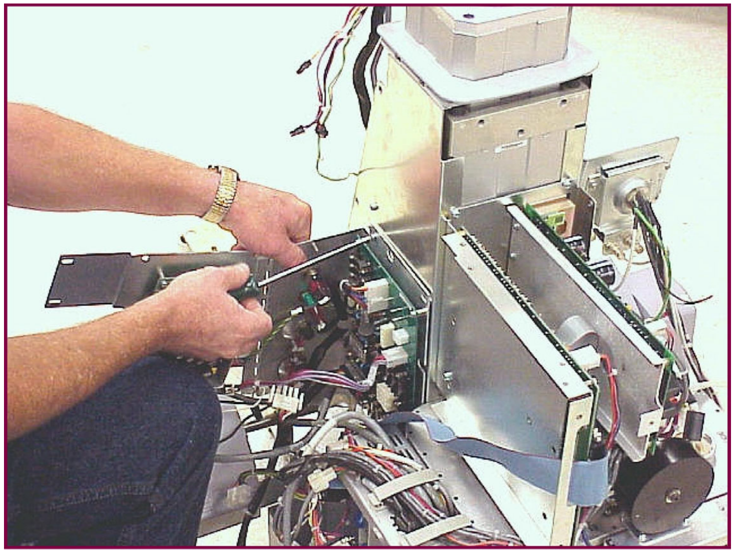
Power Panel Assembly

1. Remove eigh screws that secure the L-shaped Generator Tray cover.
2. Disconnect all wires, plugs, twist-on connectors, sub-D, etc.
3. Disconnect E1 and E2 terminals from the H.V. Tank.
4. Disconnect wire terminals from the H.V. Capacitors.
5. Separate the cables between the Power Panel Interface PCB and the Generator Tray.
6. Disconnect and route cables from Power Panel Door.
7. Disconnect cables from Power/Motor Relay PCB and pull the cables through. This is done so major assemblies can be removed intact.
8. Disconnect jack Plug from the Vertical Column Power Supply using the specialized “Magnetic Wrench” shown next.



Magnetic Wrench

9. Remove 4 screws securing the Power Panel Assembly to the Vertical Column Bracket.

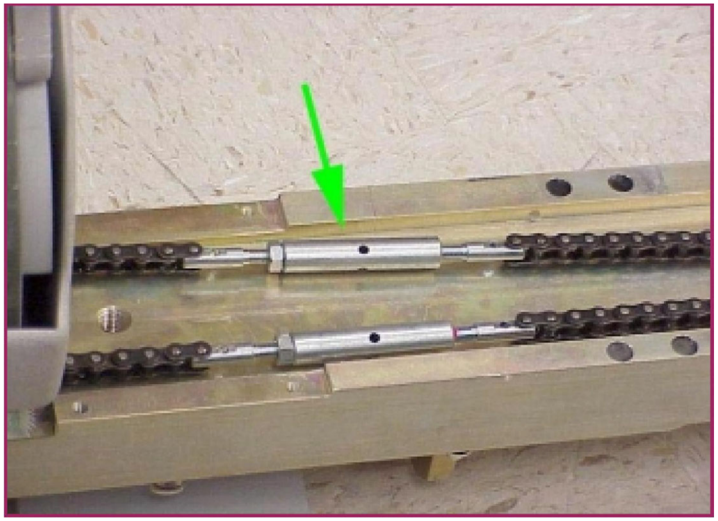


Power Panel Removal

Rear Wheels and Brakes

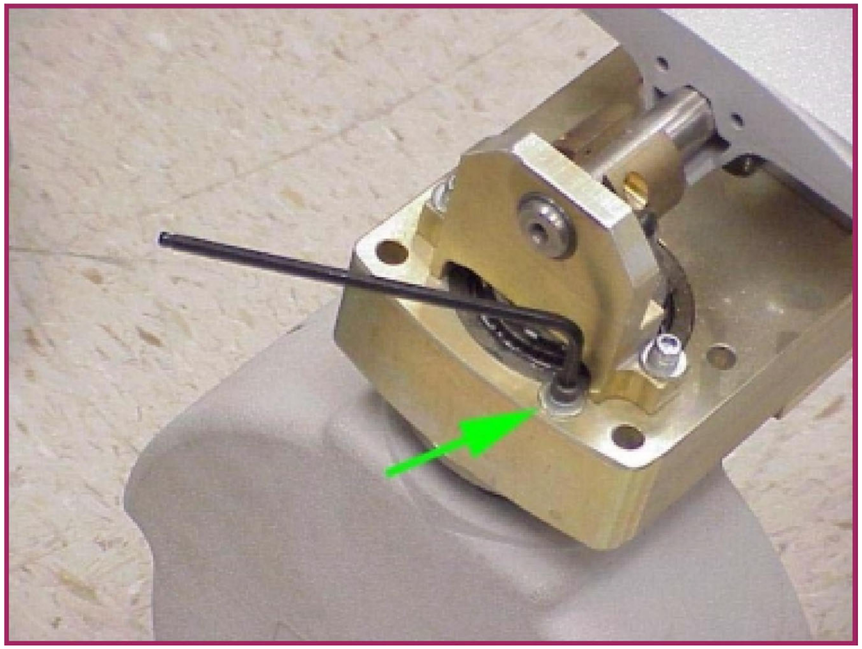
To remove the Rear Wheel Assembly perform the following:

1. Remove two screws from the End Cap Cover and remove the End Cap.
2. Jack up the Wheel Axle approximately 2 - 2.5 inches.
3. Loosen one of the turnbuckles on the steering chain.



Steering Chain Turnbuckles (View from Underneath Axle)

4. Remove the chain from around the Wheel’s sprocket.
5. Remove the Allen screw that secures caster to axle.



Allen Screw Removal

6. Remove the caster from the axle.

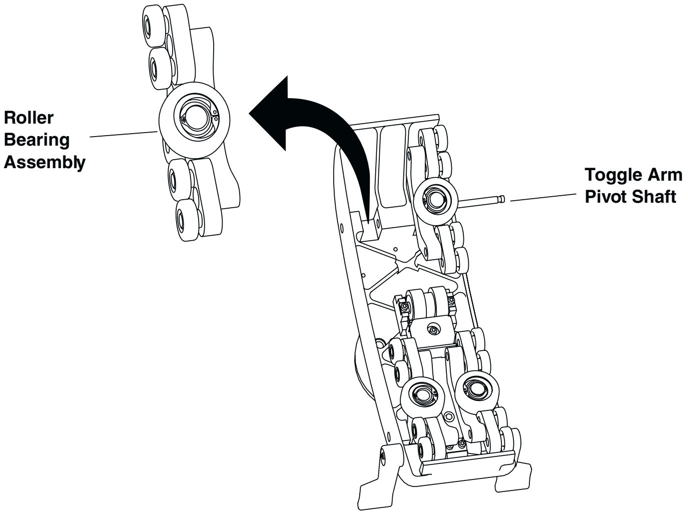
Roller Bearing Assembly

The following paragraphs describe how to remove a Roller Bearing Assembly, which is part of the Flip Flop Assembly.

The Axial or Radial Roller Bearings are replaced as a part of the Roller Bearing Assembly. The assembly can be replaced after the C-arm has been separated from the Flip-Flop Assembly.

1. Loosen the set screw that secures the Toggle Arm Pivot Shaft.
2. Pull the Toggle Arm Pivot Shaft out.

3. Remove the Roller Bearing Assembly.

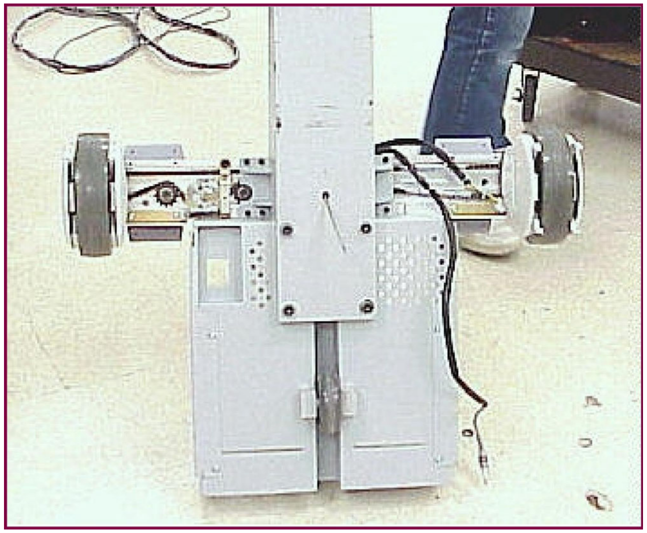


Roller Bearing Assembly Removal

Vertical Column

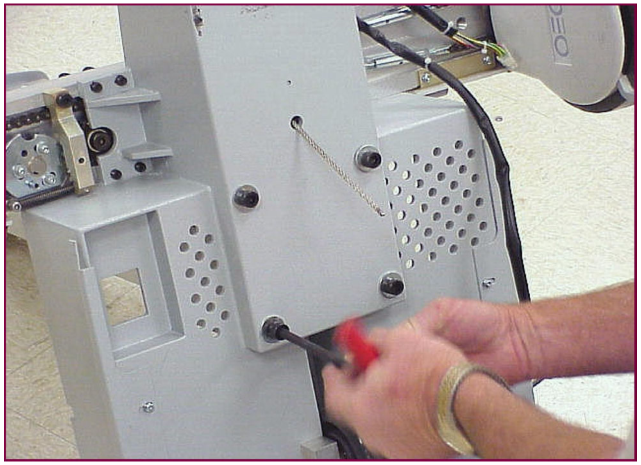
Note: You must remove all assemblies that surround the Vertical Column and all assemblies that mount on top of the Vertical Column before you can remove the Vertical Column itself.

1. Stand the Mobile C-Arm's Frame up on end as shown in the following photograph.



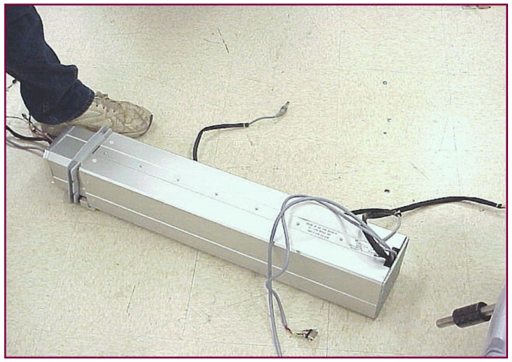
C-Arm Frame Stood on End

2. Remove the four hex keyed bolts that secure the Vertical Column to the C-Arm Frame.



Removing Vertical Column Mounting Bolts

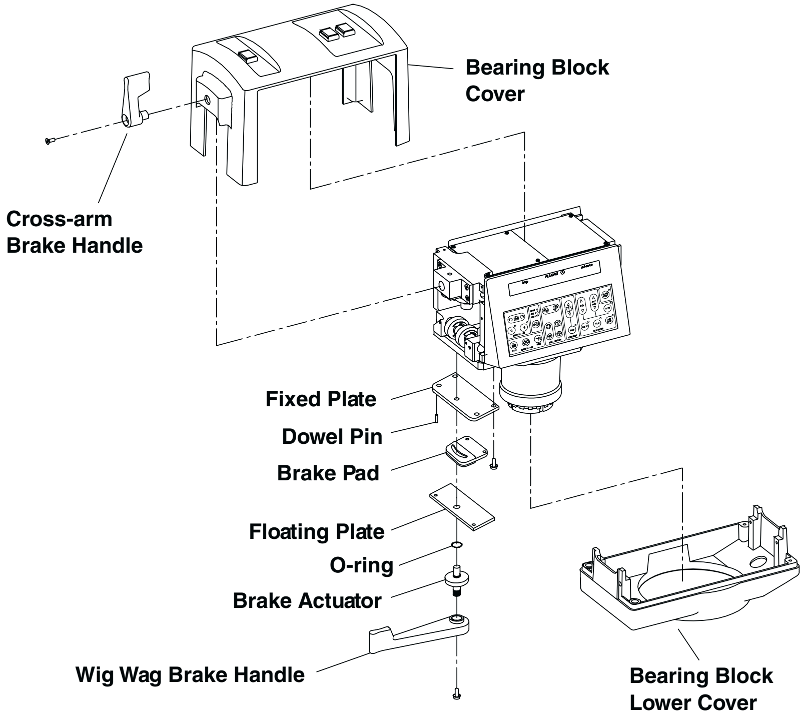
3. Separate the Vertical Column from the Frame and lay the Vertical Column on the floor. Lay the Frame down also.



Vertical Column Assembly

Wig Wag Brake

The following illustration shows the Wig Wag brake assembly.


Bearing Block Cover
Cross-arm Brake Handle
Fixed Plate
Dowel Pin
Brake Pad
Floating Plate
O-ring
Brake Actuator
Wig Wag Brake Handle
Bearing Block Lower Cover

Wig Wag Brake Assembly

To replace the Wig Wag Brake pad it will be necessary to remove the Bearing Block. Perform the following steps:

***Note**: There is not enough clearance to remove the Wig Wag Brake Pad without removing the Bearing Block.*

1. Go to the point in this document that describes how to remove the Control Panel Assemblies.

WARNING: ***Verify that the L-Arm Gas Spring locking bolt is inserted. Failure to disable the L-Arm may result in the gas spring spinning the L-Arm or Cross Arm. This could result in serious personal injury.***

2. Following the procedures, remove the Bearing Block Cover, Control Panel ASM., CPP and CPP I/O PCBs, Cross Arm and Bearing Block.
3. Unscrew the Wig Wag Brake Actuator and slide the Floating Plate off.
4. Remove 4 hex bolts from the Fixed Plate.
5. Replace the Brake Pad.